Published Monthly. Price, $5.00 per Annum.

THE JOURNAL
OF THE
AMERICAN CHEMICAL SOCIETY.

VOL. XVII.—NO. 12.

DECEMBER, 1895.

EDWARD HART, Editor, J. H. LONG, THOMAS B. OSBORNE.
COMMITTEE ON PAPERS AND PUBLICATIONS.

CONTENTS.

PAGE.
A Convenient Still for the Laboratory. By Charles E. Wait 917
On the Estimation of the Extraction in Sugar Houses. By M. Trubek 920
On Silicides of Iron. By G. de Chalmot 923
Estimation of Phosphoric Acid in Soils by Double Precipitation with Molybdic Solution and Titration of the Ammonium Phosphomolybdate with Standard Alkali. By C. B. Williams 925
On the Use of Organic Bases in the Preparation of Barium and Calcium Ferrocyanides. By Percy H. Walker 927
On the Formation of Layers in Mixtures of Acetic Acid and Benzene. By C. E. Linebarger 932
Scheme for the Identification of Acetanalide, Phenacetine, Quinine Sulphate, etc. By F. S. Hyde 933
On the Physical and Chemical Properties of Some California Oils. By Walter C. Blasdale 935
The Determination of Phosphoric Acid by the Molybdate-Magnesia Method, and by Volumetric Method. By B. W. Kilgore 941
The Volumetric Estimation of Manganese. By George Auchy 943
An Early Arrangement of the Elements. By F. P. Venable 947
On the Estimation of Phosphoric Acid by Titration of the Ammonium Phosphomolybdate Precipitate with Standard Alkali. By B. W. Kilgore 950
The Relationship of the Heat of Vaporization of Gases to their Density and also to their Boiling Point. By Wm. L. Dudley 969
The Determination of Methane and Hydrogen by Explosion. By Augustus H. Gill and Samuel P. Hunt 986
NEW BOOKS: A Manual of Qualitative Chemical Analysis; Principles and Practice of Agricultural Analysis; Laboratory Work in Chemistry 994
Books received 997
NOTE: The Banquet to Messrs. Mond and Tyrer 997
Errata 999
A Tribute to Pasteur 1000

EASTON, PA.:
CHEMICAL PUBLISHING COMPANY.

Entered at the Post Office, Easton, Pa., as Second Class Matter.

OFFICERS OF THE AMERICAN CHEMICAL SOCIETY.

President: Edgar F. Smith, Univ. of Penna., Philadelphia, Pa.
Vice-Presidents: The Presiding Officers of the Local Sections, see below.
General Secretary: Albert C. Hale, 551 Putnam ave., Brooklyn, N. Y.
Treasurer: C. F. McKenna, 221 Pearl st., N. Y. City.
Librarian: F. E. Dodge, Box 85, Long Island City, N. Y.
Committee on Papers and Publications: Edward Hart, Editor; J. H. Long; Thomas B. Osborne.
Committee on Nominations to Membership: A. A. Breneman; P. T. Austen; C. A. Doremus.
Finance Committee: Durand Woodman; A. P. Hallock; A. H. Sabin.
Board of Directors. Members ex-officio: Edgar F. Smith, Pres.; Albert C. Hale, Gen. Sec.; C. F. McKenna, Treas.; F. E. Dodge, Librarian; Edward Hart, Editor. *Term expires Dec. 1895:* C. F. Chandler; P. T. Austen; C. A. Doremus; C. E. Munroe. *Term expires Dec. 1896:* H. W. Wiley; Wm. McMurtrie; J. H. Appleton; A. A. Breneman.
Council. Members ex-officio: Edgar F. Smith, Pres.; Albert C. Hale, Gen. Sec.; Edward Hart, Editor. *Term expires Dec. 1895:* G. C Caldwell; J. W. Mallet; T. H. Norton; A. B. Prescott. *Term expires Dec. 1896:* C. B. Dudley; C. E. Munroe; Wm. McMurtrie; J. H. Appleton. *Term expires Dec. 1897:* G. F. Barker; F. W. Clarke; W. L. Dudley; E. R. Squibb.
Local Sections. Rhode Island Section: C. A. Catlin, Pres. Officer; W. M. Saunders, Sec., Olneyville, R. I. *Cincinnati Section:* Karl Langenbeck, Pres. Officer; E. C. Wallace, Sec., Room 71, Blymyer Building, Cincinnati, O. *New York Section:* P. T. Austen, Pres. Officer; Durand Woodman, Sec., 127 Pearl St., N. Y. City. *Washington Section:* Charles E. Munroe, Pres. Officer; A. C. Peale, Sec., 605 12th St., N. W. *Lehigh Valley Section:* Edward Hart, Pres. Officer; A. H. Welles, Sec., Easton, Pa. *New Orleans Section:* A. L. Metz, Pres. Officer; Hubert Edson, Sec., Bartels, La. *Nebraska Section:* H. H. Nicholson, Pres. Officer; John White, Sec., Box 675, Lincoln, Neb. *Chicago Section:* Frank Julian, Pres. Officer; F. B. Dains, Sec., 2421 Dearborn st., Chicago, Ill.

PAPERS ACCEPTED FOR PUBLICATION:

Notes upon the Determination of Nitrites in Potable Water. By Augustus H. Gill and H. A. Richardson.
Dipyridine Trimethylene Dibromide. By B. F. Flintermann and A. B. Prescott.
A Gravimetric Method of Estimating Phosphoric Acid as Ammonium Phosphomolybdate. By Thos. S. Gladding.
An Electrolytic Method for the Determination of Mercury in Cinnabar. By W. B. Rising and Victor Lenher.
Chemical vs. Bacteriological Examination of Potable Water. By W. P. Mason.
Mixed Double Halides of Platinum and Potassium. By Charles H. Herty.
The Coloring-matter of Natural Waters; its Source, Composition, and Quantitative Measurement. By Ellen H. Richards and J. W. Ellms.
The Qualitative Examination of Acetanilide. By Charles Platt.
Note on the Use of Acetylene Gas as an Illuminant for Polariscopic Work. By H. W. Wiley.
Notes on a few Pyridine Alkyl Iodide. By A. B. Prescott.
The Study of Some Gas-Producing Bacteria. By A. A. Bennett and E. E. Pannel.
The Electrolytic Estimation of Mercury. By Edgar F. Smith and Daniel L. Wallace.
Derivatives of Columbium and Tantalum. By Mary Engle Pennington.
The Action of Acid Amides upon Benzoin. By Alfred Newlin Seal.

VOL. XVII. DECEMBER, 1895. NO. 12.

THE JOURNAL

OF THE

AMERICAN CHEMICAL SOCIETY.

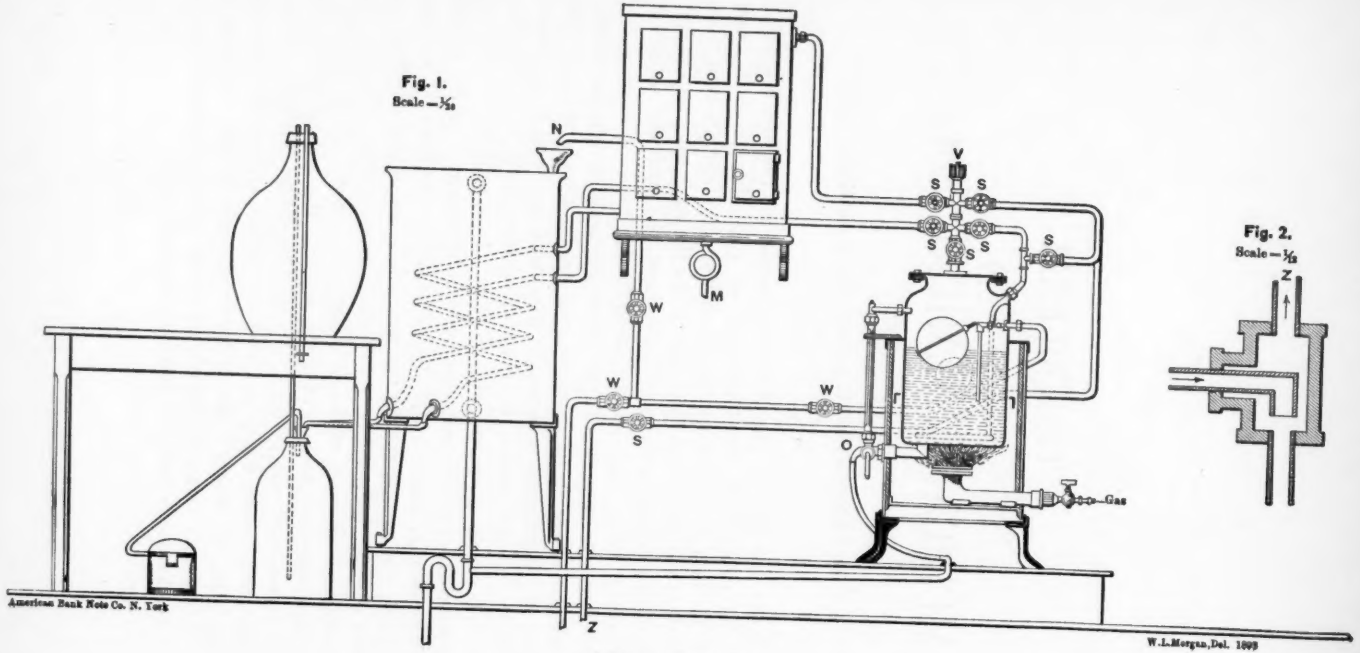
A CONVENIENT STILL FOR THE LABORATORY.[1]

BY CHARLES E. WAIT.

Received October 14, 1895.

IN the use of the apparatus purchased for the new chemical laboratories of the university, no piece has given us more satisfaction, or has been a greater success, than a new still, which is the subject of this paper. In the designing of this still I had two definite objects in view; one, the utilizing of steam from the large sixty horse-power boiler used in heating the building, and the other, a provision for making distilled water with gas, when steam from the heating-plant was not available. The still is encased in wrought-iron, with a lining of asbestos, and is provided with a float which automatically regulates the flow of water from the supply-pipe. It is a beautiful piece of apparatus, and the workmanship is excellent in every detail. The essential parts of this apparatus will be understood by consulting the accompanying figures, but a few words of explanation may be appropriate. The still has a capacity of seven gallons, and is made of heavy copper, tin-lined. It has a water-gauge showing the height of the water in the still, also an exit for steam, and safety-valve, V; inlet for steam through a coiled perforated block-tin pipe; also an outlet, O, for cleaning out the still; and there is also a heavy disk gas-burner. There is a conveniently-arranged drying-oven and a large condenser, carry-

[1] Read before the American Institute of Mining Engineers.



A CONVENIENT STILL.

ing two block-tin worms, one direct from the still, the other from the oven, both delivering water to a carboy resting on the floor. When steam is taken from the large boiler, provision is made, by an arrangement seen in Fig. 2, located at Z, beneath the floor, to cleanse the steam, before it reaches the still, from the water mechanically carried into the pipes. The water returns to the boiler, while the steam passes to the still. By the arrangement of the steam-valves, S, it is possible to deliver the steam to the empty still, where it is again washed, and may then be passed either to the oven or direct to the condenser or to both. Or the steam from the boiler may be taken direct to the oven or to the condenser or to both. When a small quantity of steam is admitted to the still, most of the distilled water is condensed in the oven and is caught in a copper tin-lined vessel underneath, through the valve, M, a part passing to the condenser and then to the glass vessel, from which it may be forced to the carboy above. When there is no steam in the large boiler gas is used, the water being kept in the still at a constant level by the automatic arrangement before mentioned and seen in the sketch. In this case the steam may be passed to the drying oven or to the condenser direct or to both, as heretofore mentioned. In the case of gas alone, the still has a capacity of about twenty-six gallons of distilled water per day, while with steam from the boiler at a pressure of five pounds, I have made distilled water at the rate of 112 gallons per day. A convenient system of piping has been arranged for supplying water to the still and condenser, to the latter at N, and under control of valves, W, as seen in the sketch. The still and condenser are both connected with the waste, and may be emptied and cleaned when necessary. Other details of this apparatus are shown in the drawings. As I have used this still constantly for a year, and fully appreciate its merits and good points, I have no hesitation in recommending the design to those who may wish a still for the purpose for which this one is used.

ON THE ESTIMATION OF THE EXTRACTION IN SUGAR HOUSES.[1]

By M. Trubek.

Received September 9, 1895.

ONE of the most important things to be considered in the control of the work in sugar houses is the exact determination of the extraction, that is, the weight of juice obtained from 100 parts of cane. This is calculated in different ways. The raw juice, as it comes from the mill, passes through measured vessels before entering the clarifiers. From the number of the vessels filled or emptied during a certain time, the quantity of juice yielded by a certain weight of cane is determined. When working with dilution, the amount of diluting material has to be subtracted. Or the bagasse, yielded by a certain quantity of cane, is ascertained, and the weight of the cane minus the weight of the bagasse, gives the extraction.

The juice is generally measured directly in the clarifiers, and after making a correction in the volume for the higher temperature the juice has when it reaches the mark in the clarifiers, the per cent. dilution, if there is any; any other quantities added and reintroduced, as lime, syrup washings, etc., are deducted.

The determination of the extraction by this method offers some difficulties. Among others, some of the "quantities reintroduced" are hard to control; the mark in the clarifiers is often not easily seen on account of the foam on top of the juice. Moreover, the person in charge will have to take his figures, as quantity of lime in the different clarifiers, number of clarifiers filled during a certain period, amount of syrup settlings left in the syrup tanks and water used for washing them, etc., from the workingmen, who do not give them with the necessary exactness.

It would be of great value, therefore, if a method could be found to determine the extraction from data found in the laboratory only.

In case the juice was not diluted, the extraction can be figured from the fiber in the cane and that in the bagasse.

[1] Read at the Springfield meeting.

In 1865, E. Icery, in an article entitled "De quelques recherches sur le jus de la canne à sucre et sur les modifications qu'il subit pendant le travail d'extraction à l'île Maurice,"[1] admitting the inconveniences in the old method proposed to determine the extraction from the bagasse of the cane under operation; the fiber of the latter is either known or has to be found by analysis. He proceeds as follows:

Two hundred and fifty grams of the bagasse, (care being taken that the latter represent a good average sample), were quickly extracted with luke-warm water and then dried perfectly in a drying stove.

Let B = weight of the wet bagasse.
" B' = " " " dry "
" C = fiber in the cane.
" x = weight of juice extracted, then $\frac{100\ B'}{C}$ will represent the weight of cane yielding the amount of the wet bagasse B, and

$$1.\quad \frac{100\ B'}{C} - B = x.$$

The extraction y per 100 parts cane is then found according to

$$2.\quad \frac{100\ B'}{C} : x = 100 : y;\quad y = \frac{x\ C}{B'}.$$

If a determination of the fiber in the cane is not made, the author sets

$C = 10$ for: Belloughet (Java cane).
Diard.
and $C = 11.5$ " : white or Tahitian.
Batavian.
Guingham (violet ribboned).
Penang.

The equations cited above (1 and 2) become simpler when calculating during the previous procedure the amount of dry bagasse per 100 parts of wet bagasse = fiber per cent. of bagasse.

I^a. $F_B : C = 100 : x$; II^a. $100 - x = E$, where F_B = fiber in

[1] *Ann. chim. et. Phys.*, 5, 350-410.

bagasse; C = fiber in cane; x = bagasse yielded by 100 parts cane; E = extraction. Very often, in order to effect a more thorough exhaustion of the sucrose in the cane, water is allowed to run in fine streams on the bagasse, coming from the first set of rollers, and the resulting bagasse contains therefore a certain amount of water not belonging to the cane. In this case I determine the extraction in the following way:

If F_{B_1} = fiber in diluted bagasse,
B = original bagasse corresponding to 100 parts of diluted bagasse,
F_C = fiber in cane,
x = bagasse resulting from 100 parts of cane,
E = extraction,

we have the following equations:

1. $\frac{F_{B_1} \cdot 100}{B} : F_C = 100 : x.$

2. $100 - x = E.$

The unknown figures are B, x, and E, as F_{B_1} and F_C are found by analysis of the cane and its bagasse.

In order to find a third equation we determine the sucrose in the cane, the extracted juice and the resulting diluted bagasse.

Let s = sucrose in cane, s_1 = sucrose in juice.
s_{B_1} = sucrose in diluted bagasse.

In $(100 - E)$ bagasse there is left $\left(s - \frac{E\,s_1}{100}\right)$ sucrose, or in 100 bagasse $\frac{\left(s - \frac{E\,s_1}{100}\right) 100}{100 - E}$.

We have therefore as the third equation:

3. $$\frac{\left(s - \frac{E\,s_1}{100}\right) 100}{\frac{100 - E}{s_{B_1}}} = \frac{100}{B}$$

After eliminating we have

$$E = \frac{a}{2} \pm \sqrt{b + \left(\frac{a}{2}\right)^2}, \text{ where}$$

$$a = \frac{100\, F_{B_1}\, (s + s_1) - 100\, s_{B_1}\, F_C}{s_1\, F_{B_1}}$$

$$b = \frac{10000\, (F_C\, s_{B_1} - F_{B_1}\, s)}{s_1\, F_{B_1}}$$

In the equation for E only the minus sign has to be taken.

Example:

	Nov. 29, 1894.	Dec. 1, 1894.
Tons ground.....	1105	1056

Regular feed on the carrier:

$F_{B_1} = 41.94$; $F_C = 10.64$; $s_1 = 10.95$; $s = 9.785$; $s_{B_1} = 4.80$.

Substituting in the equation for E we have

$$E = 89.12 - \sqrt{-7824.05 + 7942.37}$$

$$= 78.25 \text{ per cent.}$$

It is obvious that in order to get good results extreme care must be taken to obtain an average sample of the cane and the bagasse, or the results will not represent the true facts. I will admit that it is not easy to obtain such an average sample and that exact methods for determination of the woody fiber and sucrose in cane and bagasse have not yet been found. In the future I will report more fully on this subject.

CHEMICAL LABORATORY OF RACELAND
PLANTATION, RACELAND, LA.

ON SILICIDES OF IRON.

BY G. DE CHALMOT.

Received September 23, 1895.

IRON and silicon readily unite at a high temperature. Silicides of iron of a definite composition have been made by Hahn.[1] He obtained compounds of the formula: Fe_2Si, $FeSi$, and $FeSi_2$.

Since carbon readily reduces silica at the temperature of the electric arc, I expected to obtain silicides of iron with a large percentage of silicon by heating iron with silicon and carbon in an electric furnace. Iron filings, charcoal and sand were used and a silicide was obtained that contained from twenty-three to twenty-seven per cent. of silicon. In order to obtain this compound there must be an excess of sand and carbon. This com-

[1] *Ann. Chem.* (Liebig), 129, 57.

pound is white, crystalline, very hard, brittle and very little magnetic, the more so however if the percentage of silicon decreases. It conducts the electricity very well. In a pure condition it forms sometimes crystals of one cm. long. These crystals have the formula Fe_3Si_2.

	Calculated.	Found.	
Silicon	25.04	25.17	25.30
Iron	74.96	74.75	....

The specific gravity is 6.36. This compound is very resistant against acid oxidizing agents. A sample of the silicide was ground and sieved through a 100 mesh sieve.

Cold aqua regia ($1HNO_3 + 3HCl$) dissolved by frequent stirring in two days 9.86 per cent., and in nine days 10.57 per cent. Of a sample of silicide containing 12.85 per cent. of silicon 66.84 per cent. was dissolved by the same reagent in two days. The commercial silicide of iron contained about eleven to thirteen per cent. of silicon, the original silicide contained 24.1 per cent. of silicon, that treated for nine days with aqua regia contained 27.2 per cent., which shows that only iron but no appreciable amount of silicon had been dissolved. The silicide is quite decomposed by hydrofluoric acid and also if it be melted with a mixture of sodium and potassium carbonate to which some potassium nitrate has been added.

Silicides of iron of great purity can be formed from impure materials like coke and river-sand. Iron ore may replace the filings.

I have also prepared in the electric furnace silicides of a higher percentage of silicon, *i. e.*, 29.3, 33.3, and 46.2 per cent.

These silicides seem to be mixtures of the compounds Fe_3Si_2 and $FeSi_2$. The latter compound is described by Hahn as metallic greyish crystals.

The material richest in silicon which I obtained contained:

	Calculated for $FeSi_2$.	Found.
Silicon	50.26	46.22
Iron	49.84	53.76

The specific gravity of this material was 4.851. It was very brittle, crystalline, grey and nonmagnetic. Aqua regia dissolved in two days only 0.76 per cent. of the material that had been sieved through a 100 mesh sieve.

WILLSON ALUMINUM CO., SPRAY, N. C.

ESTIMATION OF PHOSPHORIC ACID IN SOILS BY DOUBLE PRECIPITATION WITH MOLYBDIC SOLUTION AND TITRATION OF THE AMMONIUM PHOSPHOMOLYBDATE WITH STANDARD ALKALI.

By C. B. Williams.

Received September 30, 1895.

THE accurate estimation of the small quantities of phosphoric acid usually present in the acid extract of soils is a question that has given no small amount of trouble in soil analysis. There seems to be two main difficulties. First, in the precipitation with molybdic solution in the presence of large quantities of iron and aluminum salts, compounds of these latter elements are also often precipitated with the ammonium phosphomolybdate, and are either dissolved by the ammonia wash or remain in the cone of the filter as phosphates, thus giving rise to high or low results, as the case may be, unless special precautions are taken. In the second place very small quantities of phosphoric acid are not precipitated readily by magnesium chloride mixture and usually require long standing to be complete, in which case the precipitate is very liable to contain an excess of magnesia, thus giving rise to higher results.

Some work in the laboratory of the North Carolina Experiment Station upon the samples sent out by Prof. A. M. Peter, reporter of the A. O. A. C. on soils, indicate that these difficulties are readily overcome by the following procedure: The hydrochloric acid extract of the soil is obtained[1] by digesting the soil in acid of 1.115 sp. gr. at the temperature of boiling water and under atmospheric pressure for ten hours. The organic acid (one per cent. citric acid and 0.63 per cent. oxalic acid solutions) extracts[2] are obtained by digestion at laboratory temperature for five hours. Care must be taken to destroy all organic matter in the hydrochloric acid extract as well as in the organic acid extracts. This is done in the former case by adding about one cc. concentrated nitric acid for every three cc. of the portion taken for analysis and evaporating to two or three cc. concentration, and in the latter cases by evaporating the extracts to dryness and igniting with the addition of a small quantity of

[1] U. S. Dept. Agr. Div. Chem., Bul. 43, page 387.

[2] See report of A. O. A. C. Reporter on Soils for 1895.

nitric acid until organic matter is completely destroyed. These residues are now dissolved up to convenient volumes, and portions corresponding to eighteen, twenty or more grams of soil, and portions of the hydrochloric acid extract corresponding to one or more grams of soil (according to the richness in phosphoric acid) are precipitated, after adding about fifteen grams ammonium nitrate, at 40° C., with a large excess of molybdic solution, (thirty cc. is usually enough), let stand four hours, filter and wash with water twice. Now dissolve the precipitate into the beaker used for precipitation with dilute ammonia, wash the filter with dilute nitric acid and add concentrated nitric acid until precipitate begins to re-form; add ten grams ammonium nitrate, digest in water-bath at 65° C., add two cc. strong nitric acid with vigorous stirring, let stand five minutes, add two cc. molybdic solution, let stand eight minutes more and filter, wash and titrate according to volumetric method in this laboratory.[1]

The results presented in the table were obtained in the course of this investigation and show very close agreement with each other on the same solutions.

VOLUMETRIC DETERMINATION OF PHOSPHORIC ACID COMPARED WITH OFFICIAL GRAVIMETRIC METHOD.

		Hydrochloric acid solution.		Citric acid solution.		Oxalic acid solution.	
No. of sample.	Official gravimetric method.	First solution.	Second solution.	First solution.	Second solution.	First solution.	Second solution.
1	0.4505	0.4170	0.4069	0.0282	0.0290	....	0.0505
	....	0.4170	0.4069	0.0282	0.0287	....	0.0505
	....	0.4170	0.4069	0.0282	0.0287	....	0.0510
	....	0.4170	0.4069	0.0282	0.0287	....	0.0510
2	0.1720	0.1826	0.1826	0.0119	0.0146	....	0.0060
	....	0.1775	0.1826	0.0119	0.0146	....	0.0060
	....	0.1826	0.1928	0.0119	0.0146	....	0.0065
	....	0.1826	0.1928	0.0122	0.0152	....	0.0065
3	0.3956	0.3767	0.3867	0.0233	0.0255	....	0.0475
	....	0.3869	0.3867	0.0233	0.0255	....	0.0475
	....	0.3869	0.3867	0.0233	0.0255	....	0.0483
	....	0.3767	0.3818	0.0233	0.0261	....	0.0483
	....	0.3767	....	....	....	....	....
	....	0.3818	....	....	....	....	....
4	0.1932	0.1828	0.1929	0.0157	....	....	0.0087
	....	0.1878	0.1929	0.0157	....	....	0.0087
	....	0.1928	0.1929	0.0157	....	....	0.0087
	....	0.1878	0.1878	0.0162	....	....	0.0084

N. C. EXPERIMENT STATION, Raleigh, N. C.

[1] See description of volumetric methods in methods of the A. O. A. C. for 1895.

ON THE USE OF ORGANIC BASES IN THE PREPARATION OF BARIUM AND CALCIUM FERROCYANIDES.

By Percy H. Walker.

Received October 21, 1895.

THE methods hitherto proposed for the preparation of ferrocyanides of barium and calcium are based either upon the decomposition of Prussian blue by the hydroxides of barium or calcium; or upon double decomposition of barium or calcium salts on the one hand, and potassium ferrocyanide on the other.

It is very difficult to prepare Prussian blue free of potassium, and the double ferrocyanides of barium or calcium with potassium are formed more readily than the simple salts. Even when the simple salts are formed, if any potassium salt has been used in the preparation, it is almost impossible to remove the whole of the potassium by recrystallization.

After trying various other methods for the preparation of barium ferrocyanide, and having very poor success, I undertook, at the suggestion of Dr. Launcelot Andrews, to prepare it according to the following method:

This method depends upon the formation of the normal strychnine ferrocyanide, the decomposition of this with ammonia, and the decomposition of the ammonium ferrocyanide by means of barium hydroxide. Strychnine was converted into the acetate by gently heating with water and the calculated amount of acetic acid. This salt, though one of the most soluble salts of strychnine, readily separates in the crystalline form from comparatively dilute solutions when allowed to cool, so it is best to keep it warm. A solution of the calculated amount of potassium ferrocyanide was added to the strychnine acetate, allowed to stand in a warm place, stirred frequently, and the white crystalline strychnine ferrocyanide, filtered and washed. After washing, the strychnine ferrocyanide was thoroughly mixed with ammonia water in excess, which decomposed it forming ammonium ferrocyanide and precipitating strychnine, which was easily separated from the solution of ammonium ferrocyanide, and could be used over again.

The solution of ammonium ferrocyanide, with excess of ammonia, was then boiled with a solution of the calculated

amount of barium hydroxide until no more ammonia was given off. The solution was allowed to cool, decanted from the crystals, and the mother liquid further evaporated. The crystals were dried in the air. They were found to contain a very slight amount of barium carbonate. On analysis, they gave 9.43 per cent. of iron and 46.98 per cent. of barium, which corresponds very closely to a salt of the composition represented by the formula $Ba_2Fe(CN)_6.6H_2O$, and which is described in Wurtz Dict. de Chim., p. 1090.

The barium ferrocyanide can be easily prepared by this method. The main objections to this method are the bulk of liquid required to dissolve the strychnine salt, and the chance for the formation of barium carbonate during the boiling of the ammonium ferrocyanide solution with barium hydroxide. This last objection can be largely avoided by boiling in a large flask, not with the direct flame, but by passing in a current of live steam. This latter method also has the advantage of inducing the formation of better crystals of barium ferrocyanide.

The following equations represent the reactions:

(1) $C_{21}H_{22}N_2O_2 + CH_3COOH = C_{21}H_{22}N_2O_2CH_3COOH.$

(2) $4C_{21}H_{22}N_2O_2CH_3COOH + K_4Fe(CN)_6$
$= (C_{21}H_{22}N_2O_2)_4H_4Fe(CN)_6 + 4CH_3COOK.$

(3) $(C_{21}H_{22}N_2O_2)_4H_4Fe(CN)_6 + 4NH_3$
$= 4C_{21}H_{22}N_2O_2 + (NH_4)_4Fe(CN)_6.$

(4) $(NH_4)_4Fe(CN)_6 + 2Ba(OH)_2$
$= 4NH_3 + 4H_2O + Ba_2Fe(CN)_6.$

Quinoline ferrocyanide was prepared in a similar manner, and this was treated directly with barium hydroxide solution, and the attempt made to get rid of the quinoline by distilling. A large amount of Prussian blue was formed, however, and the mass was thrown away. No other attempt was made using quinoline, as it was then thought that dimethylaniline would answer.

This latter method is the easiest tried and leaves little to be desired. Dimethylaniline is mixed with water, and hydrochloric acid added in slight excess. This solution then mixed with potassium ferrocyanide solution, the whole filtered and the precipitate washed with the least possible amount of water, then with alcohol, and finally with ether, and dried between pieces of filter-

paper. As little water as possible must be used, as the salt is rather soluble.

ANALYSIS OF THE DIMETHYLANILINE SALT.

Into a beaker was put 0.2220 gram with about one gram pure calcium carbonate, titrated with standard silver nitrate (one cc. = 5.829 milligrams sodium chloride) using potassium chromate as indicator. Required 18.4 cc. The end reaction was not very sharp, and after standing over night the red color disappeared. Then added more of the silver solution, making a total of 19.5 cc. One cc. of the above silver nitrate solution would be equivalent to 11.26 milligrams di-acid dimethylaniline ferrocyanide. Therefore the 19.5 cc. would correspond to 0.21957 gram.

Taken, 0.1325 gram mixed with water and two cc. dilute sulphuric acid added. Then added 17.18 cc. silver nitrate solution and two cc. solution of iron alum, titrated back with solution of potassium thiocyanate corresponding to the silver nitrate solution. Required six and one-tenth cc. Therefore 11.08 cc. silver nitrate solution used up by salt. In this the end reaction was not sharp.

Taken, 0.1341 gram salt. Treated as above except filtered before titrating back silver nitrate. Sixteen cc. silver nitrate added, four and one-tenth cc. potassium thiocyanate required. Therefore 11.9 cc. silver nitrate solution used, which corresponds to 0.1340 gram of the di-acid salt.

Mixed 0.1350 gram with water and titrated with tenth normal sodium hydroxide, using phenolphthalein as indicator.

Required twelve cc. which corresponds to 0.1351 gram of the di-acid salt.

The compound is, therefore, the di-acid dimethylaniline ferrocyanide $[C_6H_5N(CH_3)_2H]_2H_2Fe(CN)_6$, a white crystalline salt, which is somewhat soluble in water.

PREPARATION OF BARIUM FERROCYANIDE BY THE DIMETHYLANILINE FERROCYANIDE METHOD.

30.5 grams di-acid dimethylaniline ferrocyanide is mixed with barium hydroxide solution containing 22.5 grams barium hydroxide and shaken violently for some time in a flask or separatory funnel. Most of the barium ferrocyanide crystallizes out

directly and can be filtered from the liquid. The dimethylaniline is recovered by shaking the liquid with ether, which also causes more of the barium ferrocyanide to separate.

The crystals of barium ferrocyanide should be well washed, first with a little water and then with alcohol. The following equations express the reactions taking place:

(1) $C_6H_5N(CH_3)_2 + HCl = C_6H_5N(CH_3)_2HCl$.

(2) $2C_6H_5N(CH_3)_2HCl + K_4Fe(CN)_6 + 2HCl = 4KCl + [C_6H_5N(CH_3)_2H]_2H_2Fe(CN)_6$.

(3) $[C_6H_5N(CH_3)_2H]_2H_2Fe(CN)_6 + 2Ba(OH)_2 = 2C_6H_5N(CH_3)_2 + 4H_2O + Ba_2Fe(CN)_6$.

Barium ferrocyanide $[Ba_2Fe(CN)_6.6H_2O]$ crystallizes in oblique rectangular prisms belonging to the monoclinic system. The crystals are unaltered in the air at ordinary temperature, lose eleven-twelfths of their water at 40° C., the rest of the water is not driven off until the salt begins to decompose. The solubility varies from one in 584 parts cold water to one in 116 parts boiling water.[1] Dammer gives the solubility as varying from one in 1000 parts water at 15° to one in 100 at 75°.

SOLUBILITY OF BARIUM FERROCYANIDE.

Some solubility determinations were made on the salt prepared as above. The apparatus used was, I believe, devised by Dr. Launcelet Andrews. The apparatus consists of two Woulff bottles, *A* and *B*. *A* has three necks. The middle neck contains a perforated stopper holding a thermometer, the bulb of which goes nearly to the bottom of the bottle. The left hand neck has a stopper carrying a short glass tube which can be connected with the suction pump. The right hand neck has a stopper with a tube passing through and reaching to the bottom of the bottle; in fact, it is better to have the tube touch the bottom. This tube is connected to a tube passing through one of the necks of *B*, the other neck of *B* has a tube passing nearly to the bottom of the bottle. Water is put in the two Woulff bottles, and in *A* a larger amount of the salt to be tested than can be dissolved by the water. The whole apparatus is then put in a vessel of water, and air drawn through for several hours. The water in *B* preventing any evaporation from *A*. The current of air is then

[1] *Wurtz Dict. de Chim., p. 1091.*

stopped long enough to allow the undissolved portion to settle. A measured amount of the clear liquid taken out, noting the temperature, evaporated and residue weighed.

	Amount solution.	Temperature.	Residue. grams.	Parts water.	
I.	5 cc.	18° C.	0.0194	257.7	
II.	5 cc.	18° C.	0.0198	252.5	
III.	30 cc.	18° C.	0.1190	252.1	Added 50 cc.
IV.	25 cc.	17° C.	0.0936	267.0	Water to *A*.
V	25 cc.	19° C.	0.0930	268.8	
VI.	25 cc.	16° C.	0.0924	270.5	

These results fall within the limits as given by Wurtz.

PREPARATION OF CALCIUM FERROCYANIDE.

Twenty-three grams of di-acid dimethylaniline ferrocyanide mixed with water and milk of lime prepared from six grams pure lime. The mixture shaken violently in a flask, allowed to stand some time, filtered, shaken with ether to separate the dimethylaniline, separated from ethereal solution with separatory funnel, evaporated down in flask, carbon dioxide passed through, again boiled, filtered, and evaporated to about fifty cc. Alcohol then added, which causes crystals to separate. Then crystals dried between filter-paper. The crystals are of a pale yellow color and are very soluble in water. When a saturated solution is allowed to stand for a long time at the temperature of the laboratory, large flat crystals are deposited.

NOTE ON THE SEPARATION OF IRON AND ALUMINUM.

Since strychnine ferrocyanide is almost insoluble and is easily filtered, it may possibly be used to separate iron and aluminum in the following manner:

The solution containing ferric and aluminum salts is treated with excess of strychnine ferrocyanide. The Prussian blue thus formed can be filtered with ordinary filter-paper and the aluminum precipitated by ammonia from the filtrate. By this method I have easily gotten perfectly white aluminum oxide ; but have not as yet gotten the conditions for a complete quantitative separation.

I wish in conclusion to express my thanks to Dr. Launcelot Andrews, who, by his advice and assistance, rendered this work possible.

CHEMICAL LABORATORY, STATE UNIVERSITY OF IOWA.

ON THE FORMATION OF LAYERS IN MIXTURES OF ACETIC ACID AND BENZENE.

By C. E. Linebarger.

Received October 21, 1895.

Duclaux[1] states in reference to mixtures of benzene and acetic acid that "at temperatures from 15°–20° these two liquids are soluble in every proportion with each other. If a mixture of equal volumes of the two substances be cooled to about 11°, the mixture, until then homogeneous, becomes troubled all of a sudden and separates into two nearly equal layers; 0.2° of interval of temperature at most separate the two states." Duclaux then proceeds to give the results of his analyses of the two layers, as well as other results and discussions.

This account has been universally accepted, and it has passed into standard text-books that mixtures of benzene and acetic acid present at certain temperatures the phenomenon of layer-formation. This is not, however, according to fact; mixtures of *very pure* acetic acid and benzene do not separate into layers even at temperatures as low as 20°. Duclaux's observations were not made on binary mixtures of acetic acid and benzene, but upon *ternary* mixtures of *water*, acetic acid, and benzene.

A certain theoretic importance attaches itself to this question. In the course of an investigation of the vapor-tensions, both partial and total, published a few months ago in this Journal, the results found with mixtures of benzene and acetic acid were such as to preclude the possibility of layer-formation in this case. Accordingly, I have carried out some experiments on the exposure of mixtures of acetic acid, benzene, and water to varying temperatures to ascertain under what conditions of concentration and temperature, layer-formation takes place.

A cylindrical phial provided with a good cork was filled about two-thirds full of mixtures of acetic acid[2] and benzene.[3] The tube was enclosed in another larger tube, so as to prevent any possible contamination of the contents of the first tube with the baths or freezing mixtures. Several mixtures of different concentrations were exposed to a temperature of —20°, but in no case did there occur a separation into layers.

[1] *Ann. chim. phys.* [5], **7**, 267, *1876*.

[2] Purified by repeated crystallization until melting-point was not perceptibly changed no matter what the relative proportions of solid and liquid acid was.

[3] Purified by repeated treatment with strong sulphuric acid, repeated crystallizations and distillation over sodium.

14.6225 grams of a mixture containing 7.6037 grams of acetic acid and 7.0188 grams of benzene were placed in the tube described above and a few centigrams of water were added successively, the mixture being exposed to the temperature of a mixture of ice and salt, *i. e.*, about —20°, after each addition of water. Not until 0.7226 gram of water had been added did there occur a separation into layers, which persisted even at 0°, but disappeared a few degrees above.

Now, Duclaux was fully aware that the presence of water rendered it possible to cause layer formation even at temperatures above 11°, for he writes: "It is indeed not necessary to have recourse to cold to obtain the separation, and the state of unstable equilibrium in which these liquids are, can be destroyed by the addition of a third substance, as, for example, water.

"A single drop of water suffices to cause a mixture of 10 cubic centimeters of benzene and of 10 cubic centimeters of acetic acid to become troubled.

"Acetic acid crystallizing at 14° always gives a limpid solution with benzene. If it crystallizes only at 12° the mixture of equal volumes remains troubled."

Now, acetic acid melting at 14° contains not inconsiderable quantities of water, so that the behavior just described by Duclaux is what is to be expected under the circumstances. If Duclaux had taken the trouble to raise the melting-point of his acid by a few fractional crystallizations, and had employed this purified acid, there would have been one less error and its rectification encumbering the pages of chemical journals.

SCHEME FOR THE IDENTIFICATION OF ACETANILIDE, PHENACETINE, QUININE SULPHATE, ETC.

By F. S. Hyde.

Received October 29, 1895.

THE test made by boiling the substance with caustic potash and chloroform is one of the most important in the scheme given below. It is known as the "carbylamine reaction" or "isonitrile test," and is common to those compounds which are classed as *primary amines* ($R-NH_2$).

$$R-NH_2 + Cl_3HC + 3KOH =$$
$$R-N\equiv C + 3KCl + 3H_2O.$$

SCHEME FOR THE IDENTIFICATION OF ACETANILIDE, PHENACETINE, QUININE SULPHATE, ETC.

Pure substance.	Melting-point. C.	Solubility in water.	Solution of substance in water.			
			Boiled with excess caustic potash and few drops chloroform.	Ferric chloride.	Dilute nitric acid.	Bromine water.
Acetanilide (Phenyl acetamide) $C_6H_5NH.COCH_3$.	113°	Soluble in cold; more so in hot.	Odor of isonitrile.	Yellow solution. Red on boiling.	Colorless.	White crystals. Para-brom-acetanilide.
Exalgine (Methyl Phenyl acetamide) $C_6H_5N.CH_3.COCH_3$.	101°	Not very soluble, cold; easily soluble, hot.	No odor of isonitrile. Class of secondary amines.	Yellow solution. Cloudy red on boiling.	Colorless.	No precipitate.
Phenacetine (Acetylparaamidophenetol) $C_6H_4.OC_2H_5.NH.COCH_3$.	135°	Soluble with difficulty.	Odor of isonitrile.	Yellow solution. Blood-red on boiling.	Cloudy yellow solution. Crystals of nitro compound.	No precipitate.
Phenecoll hydrochloride (Glycocollparaamidophenetol) $C_6H_4<^{OC_2H_5}_{NH.COCH_2.NH_2.HCl}$.	No. M. P. HCl Comp.	Very soluble.	Odor of isonitrile.	Yellow solution. Darkens and orange precipitate on boiling.	Colorless.	No precipitate.
Salol (Phenol salicylate) $C_6H_4.OH.COO.C_6H_5$.	43°	Soluble with difficulty.	No odor of isonitrile. Yellow solution.	Yellow solution. Blood-red on boiling.	Colorless.	No precipitate cold; white cloudy compound on boiling.
Resorcin (Metadioxybenzene) $C_6H_4(OH)_2$,	118°	Easily soluble.	No odor of isonitile. Carmine-red solution.	Dark violet. Yellowish on adding drop of sulphuric acid.	Yellow solution.	Yellowish precipitate dissolving immediately.
Quinine sulphate $C_{20}H_{24}N_2O_2.H_2SO_4$.	....	Slightly soluble. With few drops of sulphuric acid dissolves with blue fluorescence.	Base precipitates and dissolves on heating.	Yellow solution.	Colorless with bluish fluorescence.	Dry substance on porcelain with weak bromine water gives green coloration on adding two or three drops ammonia water = Thallioquin test.
Antipyrine (Phenyldimethylpyrazolon) $HOC_3N_2(CH_3)_2C_6H_5$.	113°	Soluble.	Nothing.	Blood-red. Disappears on adding a drop of sulphuric acid.	Colorless.	Yellowish-white precipitate.

Phenacetine.—Contrary to some writers, phenacetine *will* give the isonitrile test, and hence cannot be distinguished from acetanilide by this reaction.[1]

Exalgine does not respond to this test because it is a *secondary* amine; hence a distinction from acetanilide, phenacetine, and phenocoll.

The odor of raspberries attributed to exalgine, when heated, is somewhat misleading. It is certainly aromatic, but may resemble either strawberries or mulberries.

By boiling acetanilide with an alkaline solution of sodium hypobromite (NaBrO) or with alkaline permanganate, the same odor of isonitrile is produced, but the reaction is complicated and not perfectly understood. However, it is assumed that the benzene ring constituting the nucleus of the compound is partially broken down by the strong oxidizing action of the hypobromite or permanganate, and thus furnishes the necessary carbon substitution in the formation of isonitrile.

In making the carbylamine, isonitrile, or "isocyanide" test, as it may be called, it is preferable to have the solution strongly alkaline in every case to insure a more complete decomposition as well as quicker reaction and a more perceptible odor.

[CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF THE UNIVERSITY OF CALIFORNIA.]

ON THE PHYSICAL AND CHEMICAL PROPERTIES OF SOME CALIFORNIA OILS.

BY WALTER C. BLASDALE.

Received September 13, 1895.

THE investigations of which I would here record the results were undertaken some two years ago with three definite objects in view; first, the accurate determination of the limits of some of the standard constants of California olive oils; second, a practical test of the application of the Babcock method of determining adulterants in butter to a similar purpose for olive oil, and finally a determination of some of the constants of three new and hitherto undescribed oils of vegetable origin. In carrying out this work I have followed in general the methods laid down by Allen for the examination of oils, introducing such

[1] *J. Anal. Appl. Chem.*, 7, 354.

modifications as more recent investigations have shown to be advisable.

The oils which have been used comprise the following samples:

1. Eleven samples of pure olive oil prepared under my own supervision from six standard varieties of olives, *viz.*, Pendulina, Uvaria, Rubra, Redding Picholine, Nevadillo blanco, and Manzanillo, according to the usual method of preparing oil for the market in California. The essential difference between the samples marked "first" and those marked "second" is that the latter include oil from the pits as well as from the pulp of the olives. A small amount of warm water was added to the pomace before pressing in the latter case. These oils, as received from the press, were washed repeatedly and filtered until clear.

2. Two samples of mustard-seed oil of California manufacture.

3. One sample of oil from the kernel of the English walnut (*Juglans regia*) grown in the southern part of the state. This oil was prepared by extraction with petroleum ether.

4. One sample of oil prepared from the fruit of our live-oak (*Quercus agrifolia*) by extraction with petroleum ether. This yields a deep brown fluorescent oil, which readily solidifies at a temperature of 10° C, and on long standing deposits waxy masses.

5. Oil prepared from the pine-nuts (probably the fruit of *Pinus monophylla*) found in our markets. This is a brown drying oil of a rather unpleasant odor and taste.

6. Oil prepared by Mr. V. K. Chesnut, from the fruit of the California nutmeg (*Tumion Californicum*).

7. Ten samples of the salad oils commonly sold in our groceries, comprising the following brands:

1. "Pure Olive Oil," J. Revalk, San Francisco.

2. "Pure California Olive Oil, Alpha Brand," Merriman Mfg. Co.

3. "California Olive Oil," Merriman Mfg. Co.

4. "Sierra Madra Olive Oil," Goldberg, Liebenbaum, and Bowen, San Francisco.

5. "Coburn's Pure Olive Oil," C. W. Coburn, San Francisco.

6. "Extra Quality Oil, Huile Vierge," A Durand et Fils, Bordeaux.

7. "Fine Salad Oil," Franco American Oil Co.

8. "Cooper's California Olive Oil."

9. "Huile D'Olive Superfin," F. Aristoy, Bordeaux.

10. "Huile Vierge," De Bossel Fil's, Marseilles.

The determinations and special tests to which these were subjected are as follows:

Specific Gravity.—This was in all cases determined by an accurately standardized pycnometer of about fifty cc. capacity.

Index of Refraction.—Determined by an Abbe refractometer of the Zeiss patern.

Thermal Degree.—By this I mean the increment of temperature resulting from mixing fifteen cc. of oil with five cc. of concentrated sulphuric acid in a calorimeter with constant stirring, using an initial temperature of at least 20° C. This method of carrying out the test was rendered necessary by the small quantities of many of the samples available; as the test is of no value except when compared with known oils this forms no serious objection to the results here presented. It is perhaps unnecessary to state that the same sample of acid was used in all the tests.

Viscosity Test.—I believe Prof. Rising was the first to suggest the possibility of using the factor representing the viscosity of the soap formed from a standard amount of oil in detecting adulterated olive oil. At his suggestion Mr. Babcock made the test with a number of samples of commercial oils, the results of which agreed entirely with those obtained by the application of standard tests to the same series of oils.[1] The method which I have used, which is essentially the one adopted by Mr. Babcock, is as follows: Fifteen grams of oil are placed in a saponification flask with about thirty cc. of water containing exactly seven and a half grams of potassium hydroxide and ten cc. of alcohol and heated on a water bath until complete saponification has been effected. The resulting soap is washed into a large evaporating dish, heated until the alcohol is expelled, diluted to exactly 500 cc. at 15° C., and the viscosity of the resulting solu-

[1] Methods of Detecting Adulterations in Olive Oil. Report of Olive Grower's Convention, held in San Francisco, July, 1891.

tion determined by means of a torsion viscometer, the results being calculated in terms of the number of grams of sugar which it would be necessary to add to a liter of water in order to produce a solution of equal viscosity. In the case of the two mustard-seed oils, it was found necessary to dilute the solution to one liter in order to obtain a workable solution. My more recent experiences would induce me to make some few changes in this process, the most important of which would be a change in the working temperature from 15° to 20° C.

Saponification Number.—By this I mean the number of milligrams of caustic potash required to saponify one gram of oil. It has been determined by the standard method, operating upon two and one-half grams of oil.

Iodine Absorption.—For this determination I used the standard method of Hübl, basing the standard of the hyposulphite solution on pure potassium bichromate according to the method of the Association of Official Agricultural Chemists.

Melting Point of Fatty Acid.—For the determination of this constant I found it most satisfactory to prepare thin but wide glass tubes on the side of which a drop of the fatty acid is allowed to solidify. This is then attached to the bulb of a thermometer, placed in a water-bath and heated until a temperature is reached at which the fat begins to run down the side of the tube. Even when the greatest care is used considerable variations will be found in the results obtained from the same sample of oil.

Elaidin Test.—In this I have followed the method of Poutet, the one based on the use of a freshly prepared solution of mercurous nitrate. The time required for the production of a good elaidin varies considerably, and I have indicated this factor somewhat roughly in the accompanying table.

Milliau's Test.—The test proposed by that author and described in this Journal, **15,** 153.

An inspection of the accompanying table will show that most of the constants obtained for the pure olive-oils agree fairly well with those obtained for European oils. The iodine absorption, however, is exceptional since many of the results here reported are higher than the commonly accepted European standards.

			Specific gravity.	Index of refraction.	Thermal degree.	Viscosity.	Melting point of fat acid.	Iodine absorption.	Saponification number.	Elaidin test.	Milliau's test.
Pure olive oil.	1	Pendulina 1st	0.9171	1.4716	47.0	648	24°	86.58	193.52	Reaction in 4 hours	No reaction
	2	" 2nd	0.9170	1.4714	47.0	593	25°	84.33	193.29	" "	" "
	3	Uvaria 1st	0.9174	1.4717	"	573	21°	86.05	190.52	.....	" "
	4	" 2nd	0.9172	1.4715	"	508	22°	85.91	190.28	" "	" "
	5	Rubra 1st	0.9165	1.4711	46.0	655	24°	83.93	191.83	Reaction in 6 hours	" "
	6	" 2nd	0.9162	1.4711	45.0	650	25°	83.72	191.86	" " " "	" "
	7	Redding picholine	0.9161	1.4711	"	587	26°	83.78	190.85	" " " "	" "
	8	Nevadillo blanco 1st	0.9168	1.4714	46.0	595	24°	86.53	192.74	" " " "	" "
	9	" 2nd	0.9169	1.4713	47.0	610	24°	85.44	192.51	" " " "	" "
	10	Manzanillo 1st	0.9163	1.4710	46.0	625	25°	80.43	191.81	" " " "	" "
	11	" 2nd	0.9166	1.4710	46.0	633	25°	79.97	191.00	" " " "	" "
Miscellaneous oils.	12	Yellow mustard seed	0.9151	1.4751	"	315	16°	98.41	173.94	Brown color no reaction	" "
	13	Black "	0.9161	1.4760	"	225	15°	103.57	174.68	Yellow brown " "	" "
	14	Walnut oil	0.9256	1.4804	110.0	100	15°	132.12	194.43	Brown color " "	Questionable
	15	Acorn oil	0.9162	1.4731	60.0	305	25°	100.66	191.26	No reaction	Slight reaction
	16	Pine-nut oil	0.9333	1.4769	71.0	100	19°	101.3	192.81	Brown color no reaction	Questionable
	17	California nutmeg oil	0.9072	1.4766	77.0	235	19°	94.71	191.39	" " " "	Reaction
	18	Revalk olive oil	0.9210	1.4730	71.0	305	33°	107.41	193.01	" " " "	"
	19	Merriman alpha oil	0.9175	1.4699	50.0	615	24°	82.20	190.17	Good reaction	.....
	20	Merriman olive oil	0.9218	1.4739	67.0	320	27°	99.08	195.04	Questionable "	Reaction
Commercial oils.	21	Sierra Madra oil, G. L. & B.	0.9157	1.4695	46.1	461	"	83.93	.....	Good reaction "	.....
	22	Coburn's olive oil	0.9172	1.4705	44.0	653	"	81.97	.....	No reaction "	No reaction
	23	Durand & Co.'s oil	0.9238	1.4754	83.0	275	33°	117.67	193.51	" "	"
	24	Franco Am. Oil Co.	0.9231	1.4751	79.0	215	35°	115.96	195.76	Reaction in 3 hours	Reaction
	25	Cooper's California oil	0.9186	1.4725	57.0	585	23°	90.57	190.83	" " " "	No reaction
	26	F. Aristoy's oil	0.9159	1.4702	45.0	568	22°	83.03	190.76	" " " "	" "
	27	De Bossis Sons' oil	0.9158	1.4703	45.0	653	23°	84.09	192.22	" " " "	" "

[1] Since these determinations were made with solutions of twice the dilution of the others and therefore with a less relative excess of potash present, they are not comparable with them.

A possible explanation may be found in the fact that many of the varieties here represented are not those commonly used for the production of oil. Similar results have been obtained by Mr. G. E. Colby.[1] In the application of the elaidin test striking differences were observed both in the character of the elaidin and in the length of time necessary for its production. On the one extreme are oils of the Manzanillo type which produce a perfectly solid mass within an hour, whereas the two Uvaria oils produced only a partial solidification even after six hours. The facts seem to indicate that the test is not as reliable as has been supposed.

From a comparison of the results obtained from the oils of known purity with those obtained from the commercial oils it will at once be seen that Nos. 18, 23 and 24 are heavily adulterated with cottonseed-oil. No. 20 shows strong evidences of adulteration though the percentage is not as high as in the other cases.

I think it is also shown that the application of the viscosity test to the detection of adulterated olive oils is entirely successful; the variations in the figures obtained from the different samples of pure oil are considerable but not so great as to admit of confusion with any of the adulterated oils. In addition to the figures presented in the table, I have obtained the following results: For cottonseed-oil 280, for sweet-almond oil 645, for rape-seed oil 670, for poppy-seed oil 95, for sesame oil 415, for lard oil 250, and for peanut oil 220, an array of figures which plainly shows the utility of this test. It will be seen that the only oils whose viscosity-constant approaches that of pure olive oil are almond, rape-seed and sesame. Of these the first is not likely to be used as an adulterant and the two latter are readily detected by other tests. The only oils showing a materially higher viscosity constant are the two mustard-seed oils, and it must be admitted that carefully proportioned mixtures of mustard and cottonseed-oils could not be detected by this test. The method promises to be of particular value in detecting lard oil for which we have had no satisfactory specific test.

Of the three hitherto undescribed oils No. 16 seem to agree in

[1] Report of California Agricultural Experimental Station, 1890.

most of its properties with other oils prepared from related plants, *viz: Pinus sylvestris*, *Pinus picea*, and *Pinus abies* in so far as these are known, and could probably be used for similar purposes.

No. 17 though obtained from a closely allied plant is an oil of quite a different character, but the data at present available is too insufficient to admit of a satisfactory prediction of its constituents. It might be of interest to note here that J. J. Rein, in a work entitled "The Industries of Japan," mentions the fact that an oil is prepared by the Japanese from the fruit of *Tumion nucifera* and used by them in their kitchens.

In conclusion I wish to express my thanks to Prof. Rising for suggestions received during the course of the work and also to the officials of the Experiment Station at Berkeley, through whose kindness I was enabled to obtain the samples of pure olive oil.

THE DETERMINATION OF PHOSPHORIC ACID BY THE MOLYBDATE-MAGNESIA METHOD, AND BY VOLUMETRIC METHOD.[1]

By B. W. Kilgore.

Received September 30, 1895.

IN a summary statement of the results obtained last year by the members of the Association of Official Agricultural Chemists and other chemists cooperating with them by the official molybdate method on a solution of C. P. disodium hydrogen phosphate, I called attention[2] to the fact that the results of nearly all of the analysts (twenty-eight) were high and some of them very materially so. The larger number of these analysts were experienced in this class of work. From this and other reasons I argued that the molybdate method, as usually worked, has a tendency to give high results, and that these high results are due to an excess of magnesium in the magnesium ammonium phosphate precipitate.

For the investigation of phosphoric acid methods for this association for 1895, two chemically pure phosphate solutions and one mixed fertilizer were employed.

[1] For description of this method, see methods of the Association of Official Agricultural Chemists for 1895.

[2] This Journal, 16, 793.

No. 1 was a solution of the same phosphate worked upon last year, and contained ten grams chemically pure disodium hydrogen phosphate to the liter, the theoretical percentage of phosphorus pentoxide in this salt being 19.826.

No. 2 was No. 1 diluted with five parts of water, and therefore contained the equivalent of 3.304 per cent. phosphorus pentoxide in 50 cc.

Fifteen chemists reported forty determinations on solution No. 1, the highest of which was 20.50 per cent., and the lowest 19.75 per cent., the former being 0.674 per cent. above the theory, and the latter 0.076 per cent. below. The average of all results was 20.044 per cent., or 0.218 per cent. above the theoretical content; the variation between the highest and lowest results was 0.75 per cent.; the variation below the theory was 0.076 per cent., and above the theory 0.674 per cent. Fourteen per cent. of the determinations were within 0.05 per cent. of the theory; thirty-three per cent. within one-tenth; and fifty-six per cent. within two-tenths. On the whole these results make a slightly better showing toward accuracy than did those of last year on the same phosphate, but like the results of last year, most of them are high. In 1894 there were two results below the theory, 19.74 and 19.78 per cent.; this year there are also two, 19.75 and 19.77, the lowest of the former being 0.08, and of the latter 0.07 per cent. below the theory; while the highest results of the two years were 0.84 and 0.76 per cent. above the theory.

On sample No. 2, containing 3.304 per cent. phosphorus pentoxide, there were forty-two determinations reported, the highest of which was 3.65 per cent., or 0.346 per cent. above the theory; and the lowest was 3.20 per cent., or 0.104 per cent. below the theory. The average of all results was 3.43 per cent., or 0.126 per cent. high. Out of forty-two results on this sample, four were below the theory. These variations being 0.10, 0.02, 0.02, and 0.01 per cent.

The foregoing adds strength to the remarks made on this subject last year, that the molybdate-magnesia method gives high results in the hands of nearly all workers, and may give extremely high ones in the hands of some.

We do not believe, however, that there is any well established

method of sufficient rapidity that suits our needs better or with which we can get better results, when proper precautions are taken, than the molybdate method.

It may be of interest here to give also a brief summary of the results on these same phosphate solutions by the volumetric method as investigated this year. The results were obtained by some of the same chemists who analyzed these samples by the gravimetric method. This was the first time the volumetric method in its present form had been used by most of them.

Thirteen chemists reported thirty-one determinations on solution No. 1 and thirty-three on No. 2 by the volumetric method. Seventy-three per cent. of all the results on No. 1 were within 0.05 per cent. of the theory, and ninety-three per cent. were within one-tenth per cent., there being only three results varying more than one-tenth. On sample No. 2 eighty-five per cent. of the results were within 0.05 per cent. of the theory, and all were within one-tenth.

The results upon which the foregoing discussion is based will appear in the proceedings of the A. O. A. C. in the "Report on Phosphoric Acid," made by the writer to that association at its recent meeting.

NORTH CAROLINA EXPERIMENT STATION,
Raleigh, N. C.

THE VOLUMETRIC ESTIMATION OF MANGANESE.

BY GEORGE AUCHY.

Received October 22, 1895.

IN this Journal, **17**, 5, Mr. W. H. Thomas describes his experience with Low's and with Volhard's method of determining manganese. The latter he finds reasonably accurate. The former not at all so. Some ten or twelve years ago, in the transactions of the American Institute of Mining Engineers, Williams' method in steel, which is based on the same principle as Low's method in ores, was the subject of considerable controversy; some claiming, others disputing its accuracy. And although the weight of the testimony seemed to be in favor of the method, nevertheless, the close of the discussion left the matter still somewhat in doubt.

Are methods based upon this principle reliable? Mr. Thomas'

experience with Low's method is further evidence to the contrary. But as regards Williams' method, perhaps it may be said that Mr. Thomas' results are not in evidence, inasmuch as potassium chlorate and strong nitric acid are stronger oxidizing agents than bromine water, and may therefore be depended upon to oxidize the manganese completely to manganese dioxide, even if the latter cannot be. But Mr. Stone's and others work is against this assumption; also the following results obtained from manganese ores:

	Williams' method (practically) per cent.	Volhard's method. per cent.
Ore No. 1	51.71	53.04
" " 2	51.58	53.00
" " 3	44.88	46.80
" " 4	43.00	46.24
" " 5	41.22	42.64
" " 6	34.39	40.00
" " 7	44.88	46.40
" " 8	31.61	43.76

Among steel works chemists, Williams' method is very popular on account of its great ease and simplicity. Comparatively few, perhaps, use Volhard's method. And it is therefore important that the reliability of the former method be more fully and definitely established. So far, the evidence in its favor is strong and positive. But there is still room for doubt. More work seems to be required to fully settle the question, and it would be well for chemists who use this method, to patiently check with Volhard's method for a considerable time, (using different lots of chlorate) and communicate their results and opinions to the Society. I say Volhard's method, because the gravimetric is too cumbersome for such an extended use, and is probably moreover not any more accurate—perhaps not so much so—as Volhard's.

My own experience with Williams' method leads me to believe that it usually, but not always, gives accurate results. And I am disposed to think that if chemists who have repeatedly obtained good results with that method, and who have therefore every confidence in it, would nevertheless keep on for an extended period checking their results by Volhard's method

they would sooner or later be treated to a disagreeable surprise such as illustrated by the last four of the following results:

		Williams' method. per cent.	Volhard's method. per cent.
Heat	114	0.42	0.42
Rolled steel	...	0.43	0.45
Heat	116	0.50	0.50
"	120	0.40	0.41
"	121	0.42	0.42
Tire steel	...	0.92	0.94
Heat	125	0.48	0.54
Tire	...	1.04	1.20
Heat	162	0.37 and 0.42	0.45
"	163	0.40	0.48

With heat 163 Williams' method was given up.

With regard to the method of oxidizing to permanganate by lead oxid and titrating with arsenious solution, without having given the method actual trial, I am nevertheless convinced that it gives uniformly low results, from the fact that while it was in use at these works, 135 and 140 pounds of ferromanganese per charge was needed to bring the manganese content to the required point, working by this method, while now, with Volhard's method in use, only ninety and 100 pounds are used to bring the same result. But the lead oxid used in the method was the tetroxide. Probably by the use of dioxide, good results may be obtained.

For the benefit of chemists, who have never used Volhard's method, and who feel disposed to give it a trial, for the purpose I have suggested, I beg to call attention to certain precautions which are essential to a successful practice of the method.

1. In boiling off the nitric acid with sulphuric acid, it is very essential to avoid too much sulphuric acid, as otherwise the bumping and spattering will be so violent as to altogether spoil the test.

2. The dry mass should be taken up with *hot* water, allowing the dish first only a minute or two for cooling. If the dish be allowed to cool completely, and cold water be added, and then boiled up, very frequently a red ferric sulphate carrying much manganese will remain insoluble, no matter how much additional sulphuric acid be added. Even this precaution is value-

less, however, if the dry mass be heated too long. But this residue can be brought into solution by decanting the clear solution and then heating for some time with sulphuric acid. But to save time its separation should of course be prevented in the first place.

3. In steels high in manganese it is advisable, and in steels low in manganese it is absolutely essential that not too much zinc oxide be used; as it will separate out when the solution is heated, if much has been used, and will retard the settling of the manganese dioxide if the steel be high in manganese, and will completely prevent it if the steel be low in manganese, (0.18—0.24 per cent.) and thus make the observation of the end of the titration impossible. Before the zinc oxide is added, therefore, the solution should be in as small a bulk as convenient and be as nearly neutralized with sodium carbonate as possible.

4. When titrating with permanganate, the reddish color caused by the permanganate should be completely changed into clear yellow by shaking the flask before more permanganate is added, and at the end the liquid must be distinctly and permanently rose colored—that is, it must retain its color through a dozen good shakings. It is well, toward the end, to add the permanganate four drops at a time (when two drops equal one-tenth cc.) till the distinct rose-tint is reached, and then deduct one-tenth cc. from the reading of the scale.

It may be a convenience to state the method in detail. Take exactly three and three-tenths grams in a six-inch evaporating dish. Cover and dissolve on the hot plate in forty cc. of nitric acid containing a little more than half of strong acid. Add eight cc. (no more) strong sulphuric acid. If, however, the liquid becomes cloudy on boiling, the violent bumping and spattering before referred to will inevitably occur as the boiling progresses further. Add then at once some strong hydrochloric acid, and transfer to a wire gauze, where boil down rapidly over a good strong flame till the mass is nearly dry—a little pastiness still remaining here and there. It is best to remove the cover when the liquid gets pasty. Allow to cool a minute or two. Take up with hot water and boil a few minutes. Cool by placing in a larger dish of cold water. Pour into a 500 cc. measuring flask. Nearly neu-

tralize with sodium carbonate. Add zinc oxide emulsion until sudden stiffening of the solution. Dilute to the mark. Pour in a dry beaker, mix with rod, and pour through a very large ribbed filter into a 250 cc. measuring flask. When the liquid has reached the mark, withdraw, and transfer to a 500 cc. Erlenmeyer flask. Heat to boiling. Add nearly the full amount of permanganate of strength exactly 0.0055, if the percentage of manganese is approximately known. If not add only one and a half cc. permanganate, and boil until the manganese dioxide separates in flakes, and the liquid becomes yellow. Finish the titration shaking after each addition of permanganate till the yellow reappears. The number of cc. permanganate divided by ten will give the percentage of manganese.

Where the method is in daily use, it will be well to use for neutralizing before adding zinc oxide common sal soda instead of the expensive chemically pure carbonate. But this will add about 0.03 per cent. to the manganese, and must be determined and deducted. The sal soda can be procured at grocery or drug stores. Two pounds in two liters of water (and filtered) is a convenient solution.

The impurity is best determined by doing a steel with pure sodium carbonate, then with the sal soda. For convenience, the amount of the soda solution required to nearly neutralize the manganese solution is noted, and that amount is then at once added in subsequent determinations.

AN EARLY AMERICAN ARRANGEMENT OF THE ELEMENTS.

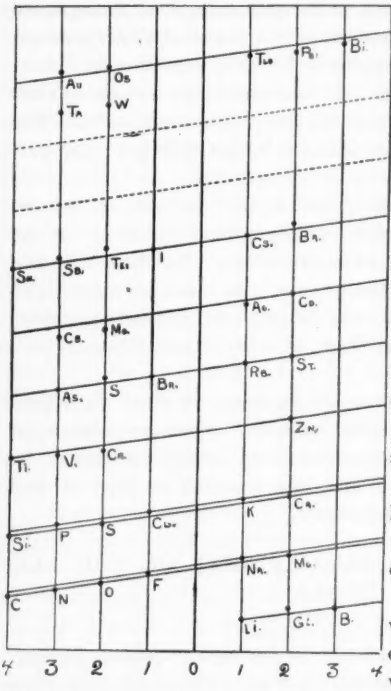
By F. P. Venable.

Received September 23, 1895.

IN going over the papers published during the period immediately following the announcement of the Periodic Law, there is one which possesses especial interest for an American.

It is the "Synoptical Tables of the Elements" by Dr. L. R. Gibbes, of Charleston, appearing in the publications of the Elliott Society in 1875. This table had been prepared some two or three years previously for the use of his classes. In it a professor in a remote and small American college worked out for himself, evidently in ignorance of the arrangements of Mende-

leeff and Meyer, some of the most important principles of the Periodic Law. The evidence of this ignorance is presumptive; first, because his table was very crude and certainly would not have been offered to his classes had the author known of the much superior ones which had already appeared; secondly, he carefully mentions all authorities known to him and upon whom he had drawn in the construction of his table. His library was an antebellum one and the authorities were old. Still he forestalls two or three late authors in his methods of graphic representation of the law.



His table was designed to exhibit:

1. The groups of elements.
2. The atomic weight of each element.
3. The character of each, as perissad or artiad.
4. Their atomic equivalence or atomicity.
5. The electro-chemical character.

In his table the elements were arranged in the order of their atomic weights, but with a good many gaps unfilled, from imperfect knowledge. He remarks upon the "continuity or regularity in the series of numbers" as being very striking.

In his diagram he gives upon the horizontal axes, right and left, from the centre, the positive and negative electricities as abscissas. The atomic weights are laid off as ordinates upon the vertical axes, rising from a zero atomicity. This gives the ele-

ments in an ascending scale of atomic weights, though they are broken up into three series. With much acute reasoning and insight, Gibbes shows that the three series may be exhibited in continuity as one, that is, by the use of an Archimedean Spiral whose radius vector increases by sixteen units in one revolution.

This is the arrangement of Lothar Meyer and de Chancourtois and the spiral suggested by Mendeleeff. His diagram will, on investigation, be seen to be based on the same principles as those of Spring, Reynolds and Crookes.

The author goes further and anticipates some of the geometrical work of Haughton. He observes that no linear equation can be constructed to give more than rude approximations to the atomic weights, and that to construct curves, two points of inflection or contrary curvature must be given. These are the serpentine cubics afterwards worked out by Haughton.

He cautions against laying too much stress upon such arithmetical and geometric exercises.

It seems remarkable that, with so imperfect a table, so much of the later work, done with the perfected tables given by the authors of the Periodic Law, should have been anticipated, especially when we notice how slight was Gibbes' idea of periodicity. He gives in his table seven groups, it is true, four negative and three positive, but they are very poorly filled out, and he shows no completed period of seven in the entire table. His observed regularities can scarcely refer to periodicity, still he makes some mention of what Meyer calls double periodicity, though of course not under this name.

Dr. Gibbes was a professor in the College of Charleston, a fine physicist and a thoughtful chemist. These "Synoptical Tables" which he built up upon the work of Dumas, Gladstone, Cooke, Odling and Barker, speak highly for his insight and power of reasoning.

UNIVERSITY OF NORTH CAROLINA, Sept. 1895.

10-27-95

ON THE ESTIMATION OF PHOSPHORIC ACID BY TITRATION OF THE AMMONIUM PHOSPHOMOLYBDATE PRECIPITATE WITH STANDARD ALKALI.[1]

By B. W. Kilgore.

Received September 30, 1895.

IN November, 1894, the writer published[2] some results of an investigation of the method on this principle as originally described[3] by Mr. H. Pemberton, Jr., and as modified by the writer, together with an account of some work upon molybdic solutions and temperatures of precipitation best suited for obtaining ammonium phosphomolybdate uncontaminated with molybdic acid.

These investigations were undertaken in part by the writer as reporter of the Association of Official Agricultural Chemists on methods for determining phosphoric acid for 1893–94, to see if the volumetric method was sufficiently accurate and trustworthy, or if it could be developed into a sufficiently reliable method to be used by these chemists in their official work.

The present official gravimetric method is rather long and often gives quite varying results in the hands of different analysts and not always the most concordant ones in the hands of the same analyst. These two objections to the molybdate method, together with the immense volume of phosphoric acid work which has to be done in connection with "Fertilizer Control Stations" and fertilizer factories makes it doubly important that a quick and accurate method for phosphoric acid estimation should, if possible, be found.

The volumetric method seemed to promise well, and it was accordingly sent out, both as originally described by Pemberton and as modified by the writer, to various official and other chemists interested in phosphoric acid work for trial. Three phosphate samples were prepared upon which to conduct the investigations.

No. 1 was a mixture of cottonseed meal and castor pomace, containing about two and a half per cent. phosphorus pentoxide.

No. 2 was an acid phosphate containing about seventeen per cent. phosphorus pentoxide.

[1] This with some additional matter will appear in a bulletin from the North Carolina Experiment Station.

[2] This Journal, **16**, 765.

[3] This Journal, **15**, 382.

No. 3 was a solution of chemically pure disodium hydrogen phosphate ($Na_2HPO_4.12H_2O$), containing 19.826 per cent. phosphorus pentoxide.

The results obtained in this laboratory[1] on these samples by the different methods and presented to the association are shown in Table I.

These results, with a few exceptions, indicate well for the volumetric method, especially the method as described by the writer, there being only one result (20.10 per cent. on sample 3) by this method without the reasonable error of analysis. The larger percentage of the results however on samples 2 and 3 by the method as carried out by Pemberton are high.

The corresponding results on these samples by some sixteen other chemists were not as a whole nearly so encouraging as those presented above, which was likely due to the greater familiarity with the volumetric method in this laboratory.

Then, too, the very large amount of wash water (amounting in some cases to more than a liter) found necessary by a great many to remove free acid from the precipitate made the washing tedious and gave the method little or no advantage in most hands as regards time over the gravimetric method and no advantage in point of accuracy, the latter being especially true when it is made known that now and then unaccountably high results would be obtained by many in the midst of good ones. Notwithstanding these difficulties, most of the chemists who had tried the volumetric method in the different forms in which it was worked up to this time, considered their results on a whole as encouraging, but not such as to give them any considerable faith in the method, especially for high percentages.

At this point the writer again commenced studying further the volumetric method in its various phases and trying numerous modifications to it.

The results obtained last year[2] by the writer's modification of the Pemberton method, consisting of a different molybdic solution and temperature of precipitation, were much more uniform and satisfactory than those obtained by the original Pemberton method on the same samples.

[1] The results of other chemists on these samples will be found in Bul. 43, Div. Chem. U. S. Dept. Agr., page 81.

[2] This Journal, 16, 767.

TABLE I. TOTAL PHOSPHORIC ACID IN ABOVE SAMPLES 1, 2, AND 3.

Analyst.	No. 3. Methods and washings.					No. 2. Methods and washings.					No. 1. Methods and washings.				
	Official gravimetric.	Volumetric as carried out by Pemberton.	Washings.	Volumetric as carried out by Kilgore.	Washings.	Official gravimetric.	Volumetric as carried out by Pemberton.	Washings.	Volumetric as carried out by Kilgore.	Washings.	Official gravimetric.	Volumetric as carried out by Pemberton.	Washings.	Volumetric as carried out by Kilgore.	Washings.
	Per cent.	Per cent.	cc.	Per cent.	cc.	Per cent.	Per cent.	cc.	Per cent.	cc.	Per cent.	Per cent.	cc.	Per cent.	cc.
W. M. Allen...	....	....	....	....	....	17.13	...	....	17.15	650	2.52	....	....	2.50	350
	....	....	....	....	....	17.18	....	...	17.00	to	2.52	....	....	2.55	to
	....	....	....	....	....	17.15	....	....	17.10	800	....	....	....	2.55	400
F. B. Carpenter	19.93[3]	20.00	....	19.85	....	....	...	....	....	....	....	....	....	....	....
	19.94[3]	20.15	....	20.10	....	17.04	17.10	....	17.15	....	2.65	2.58	....	2.55	....
	19.93	....	....	....	....	17.12	17.15	....	17.15	....	2.61	2.63	....	2.58	....
	19.91	....	....	....	....	17.10	....	....	....	....	....	....	....	....	....
B. W. Kilgore.	20.06	20.35	650	19.85	....	17.17	17.20	500	17.15	450	2.42	....	....	2.50	250
	19.93	20.15	850	19.95	650	17.12	17.40	500	17.10	450	....	....	....	2.45	250
	19.83[4]	20.15	850	19.90	850	16.98[1]	....	....	16.97	450	....	....	....	....	....
	19.83[4]	20.10	1,000	19.90	800	16.98[1]	....	....	17.00	500	....	....	....	....	....
	19.91[3]	....	....	19.80	1,000	....	....	....	17.10	500	....	....	....	....	....
	19.85[3]	....	....	....	....	....	...	....	....	....	....	....	....	....	....
C. B. Williams.	20.03[3]	....	....	....	....	....	....	....	17.10	500	....	....	....	2.50	500
	20.05[3]	....	....	....	...	16.96[4]	....	....	17.10	500	....	....	....	2.50	....

[1] The "white" precipitate was dissolved and reprecipitated.

[3] Precipitated with magnesia mixture; direct.

[4] One gram citric acid added before precipitating with magnesia mixture.

This modified method gave quite as good results in the writer's hands as did the official method. It was therefore decided to use this modified procedure, that is, precipitation at 60° C., and with the official molybdic solution as the starting-point for the investigation.

Knowing that the deposition of molybdic acid was the cause of the trouble in the volumetric method, various ways of getting rid of it were tried. One attempt was to dissolve the ammonium phosphomolybdate in the least possible quantity of concentrated ammonia, thus changing any molybdic acid to ammonium molybdate, acidifying with nitric acid, evaporating to dryness and heating to drive off all nitric acid. This was not practicable for other reasons than that molybdic acid was again formed from the ammonium molybdate on heating to a temperature that would drive off nitric acid. Distillation of the ammonia from the "yellow precipitate" and the calculation of the phosphoric acid from that would not do in that the deposit of molybdic acid carries ammonium molybdate with it. Finally it was determined to try to find wash solutions, which would dissolve molybdic acid, but not ammonium phosphomolybdate.

Using a chemically pure disodium hydrogen phosphate containing 19.826 per cent. phosphorus pentoxide, the following results were obtained with different strengths of nitric acid for washing, finishing with potassium nitrate solution and water to remove nitric acid.

WASH SOLUTIONS.

No. of times washed with water by decantation.	No. of times washed with dilute nitric acid by decantation.	No. of times washed with three per cent. potassium nitrate by decantation.	Washed on filter with water. cc.	5 cc. 1.42 sp. gr. nitric acid in 100 cc. water. per cent.	10 cc. 1.42 sp. gr. nitric acid in 100 cc. water. per cent.	20 cc. 1.42 sp. gr. nitric acid in 100 cc. water. per cent.	Washed with water only. per cent.
.	1	2	275	....	....	19.80	....
1	1	1	275	....	19.84	....	....
2	1	.	275	19.98	....	....	....
.	2	1	400	....	....	19.80	....
.	2	1	400	....	19.87	....	....
1	2	.	275	19.80	....	....	....
3	.	.	400	....	....	....	19.98
.	2	1	230	....	19.87	....	....
.	2	1	350	....	19.83	....	....
3	.	.	700	....	....	....	19.93
3	.	.	550	....	....	....	19.87

The washing with dilute nitric acid and three per cent. potassium nitrate solution was always by decantation, using fifty cc. to seventy-five cc., agitating thoroughly and allowing the precipitate to settle completely each time. When the washing was with water alone, the results are high, while washing twice by decantation with the wash containing ten cc. 1.42 sp. gr. nitric acid in 100 cc., once by decantation with three per cent. potassium nitrate solution, and then with about 300 cc. water on the filter, the results are close to theoretical ones.

Solubility of Molybdic Acid in Various Wash Solutions.—It now seems important to investigate the solubility of molybdic acid in various solutions which might be used for washing. The results of this work are contained in the table below and the solubility is expressed in terms of the number of cc. of the standard volumetric alkali neutralized by the molybdic acid dissolved. 100 cc. of this alkali equals 32.38 cc. normal alkali.

SOLUBILITY OF MoO_3 IN VARIOUS WASH SOLUTIONS.

No.	Amount of MoO_3, grams.	Amount of solution cc.	Time of standing, hours.	Water.	2 cc. 1.42 sp. gr. nitric acid in 100 cc. Water.	5 cc. 1.42 sp. gr. nitric acid in 100 cc. water.	10 cc. 1.42 sp. gr. nitric acid in 100 cc water.	20 cc. 1.42 sp. gr. nitric acid in 100 cc. water.	2.5 per cent. potassium nitrate.	5 per cent. potassium nitrate.	5 per cent. sodium nitrate.
1	2	100	1	1.4[1]	..	..	5.6	6.8	0.4[2]	0.5[2]	0.5[2]
2	1	100	2	..	7.4	8.1	8.8	..	..	7.5[2]	..
3	.	...	.	..	..	..	2.8[3]	..	3% KNO_3	..	..
	1	100	½	..	1.3[2]	1.5	2.0, 2.3	2.8	0.92	..	..
	1	100	1	0.45[2]	0.8	1.5	2.5	3.1	2.5	..	..
4	1	100	½	..	2.4[2]	3.55[2]	5.15	6.3	0.92[2]	..	..
	1	100	1	..	2.9[2]	4.7[2]	7.3	8.85	1.0[2]	..	..
5	1	100	.	..	..	..	2.2	..	0.8	..	..
			½	1.4[4]	..	..	2.2	..	0.7	..	..
	1	100	.	..	..	..	2.8	..	0.8	..	..
			1	..	..	..	2.8	..	0.8	..	..

[1] Stood eighteen hours and then filtered turbed, though double filter was used; result too high.

[2] Filtered turbid; results too high.

[3] Used as in washing the yellow precipitate. One portion of 100 cc. was added, stirred and allowed to stand fifteen minutes, and filtered off; then another 100 cc. portion was added and titrated in the same way.

[4] Stood twenty-four hours before a clear filtrate could be obtained.

These solubility determinations were made by allowing 100 cc. of the respective solutions to stand in a beaker with the molybdic acid for the time indicated in the table, stirring once or twice to keep the molybdic acid in contact with the liquid, but allowing sufficient time before filtration for most of it to settle to the bottom of the beaker. The washes were then filtered through double filters, evaporated to dryness (when nitric acid was present), heated in an air-bath until nitric acid was driven off, and titrated. It was found very difficult to prevent the molybdic acid from passing through the filter when water was used as the solvent. It would remain suspended in a very finely divided state in water for twenty-four hours and pass through the filter. The results for the water solubility are therefore generally too high. This is also true to a less extent of the solubility in two and a half, three, and five per cent. potassium nitrate solutions, and in the five per cent. sodium nitrate solution; and to a still less extent of the solubility in two and five cc. nitric acid solutions.

The results are not all uniform but fairly so when the same molybdic acid was used. None of these molybdic acids were pure.

Numbers 1 and 2 contained considerable quantities of ammonium nitrate and ammonium molybdate, and perhaps some sodium molybdate. Numbers 3, 4, and 5 were washed by decantation for a day or more with large quantities of dilute nitric acid, and finally once or twice with water, and contained, so far as we ascertained, only ammonium molybdate as impurity. The impurities did not, we think, materially affect the solubility of these acids in the wash solutions. The results, at any rate, are of value in showing the comparative solvent action of the different washes for molybdic acid under conditions similar to those in which they are used in the method.

They show that water, and sodium and potassium nitrate solutions have very little solvent action upon molybdic acid; while that of the stronger nitric acid solutions is quite considerable. After all, these results may represent more nearly what we want than they would, had pure molybdic acid been

used; for in the volumetric method it is not a solvent for molybdic acid alone that is wanted, but for a mixture of molybdic acid and ammonium molybdate perhaps in quite variable quantities.

Of the dilute nitric acid washes, the one containing ten cc., 1.42 sp. gr., nitric acid in 100 cc. of the wash was adopted because it possesses good solvent power for molybdic acid and is of practically the same acidity as the solution in which the precipitation of ammonium phosphomolybdate is made in the official method. The official molybdic solution contains nearly fifteen cc., 1.42 sp. gr., nitric acid in fifty cc.; and a solution requiring fifty cc. of molybdic solution to precipitate the phosphoric acid in it usually has a volume near 100 cc.; the two would give a volume of 150 cc, containing about ten cc. nitric acid in the 100 cc.

We know that precipitation is complete in a solution of this acidity, and no solvent action takes place on long standing. It therefore seems reasonable to conclude that nitric acid of the same strength would exert little or no solvent action on the ammonium phosphomolybdate in the short time required to wash the precipitate.

SOLUBILITY OF AMMONIUM PHOSPHOMOLYBDATE IN THE FOREGOING WASH SOLUTIONS.

It now appeared desirable to investigate the solubility of ammonium phosphomolybdate in these same wash solutions. This was done by preparing a pure phosphomolybdate from sodium phosphate by precipitating with a deficient quantity of molybdic solution, pouring off the filtrate, washing by decantation with dilute nitric acid, and finally with water to remove most of the nitric acid, and drying to constant weight at 130° to 150° C. This phosphomolybdate contained 3.789 per cent. phosphorus pentoxide, the theory being 3.783, showing that it was practically pure. The solubility is expressed in terms of the number of cc. of standard volumetric alkali required to neutralize the phosphomolybdate dissolved. One cc. of this alkali equals one milligram phosphorus pentoxide.

SOLUBILITY OF AMMONIUM PHOSPHOMOLYBDATE IN WASH SOLUTIONS.

	Amount of solution.	Time of standing—hours.	Water at 65° C.	Water at laboratory temperature, about 27° C.	2 cc. HNO_3 in 100 cc. wash.	5 cc. HNO_3 in 100 cc. wash.	10 cc. HNO_3 in 100 cc. wash at 65° C.	10 cc. HNO_3 in 100 cc. wash at laboratory temperature.	20 cc. HNO_3 in 100 cc. wash.	3 per cent. KNO_3 solution.
0.75 to 1.4 grams substance stood in 500 cc. of the solution for the time indicated, and 200 cc. was taken each time for the test.	200	24	5.2[1]	0.85[1]	0.2	0.25	20.1	0.6	0.75	0.5
	200	106	6.0[2]	3.0[3]	2.05	5.5	16.75[2]	6.75	11.45	4.35
Results from allowing precipitates from 20 per cent. phosphate to stand in these solutions.	200	½	..	none	..	none	..	none	none	none
	200	1	..	trace	..	trace	..	trace	trace	trace

From 0.75 to one and four-tenths grams of the prepared phosphomolybdate was shaken up in flasks with 500 cc. of the wash solutions. Two hundred cc. of this was filtered off at the end of twenty-four hours and 106 hours respectively, evaporated to dryness (when nitric acid was present), the nitric acid driven off, and the residue titrated. The phosphomolybdate settled in only two or three of these washes in less time than twenty-four hours, and even then the very fine particles remained suspended in the water solutions, and it was found impossible to get clear filtrates from them. The results for water-solubility are therefore too high. For the reason just stated the solubility of ammonium phosphomolybdate in the washes could not be determined for the times they would ordinarily stand in contact with the precipitate in washing by the use of the pure molybdate. If, however, the solubility of even this pure phosphomolybdate was proportional to the time of standing in the washes, the amount that would have been dissolved by all the washes (dilute nitric acid, potassium nitrate, and water) used in washing a precipitate in the ordinary thirty minutes required for washing could hardly have been found. I calculated that on this basis a plus correction of

[1] These filtered very turbid; they had not settled in twenty-four hours.
[2] These stood at laboratory temperature (about 27° C.) after first twenty-four hours.
[3] Filtered turbid; results too high.

about 0.016 per cent. would be necessary on basis of two-tenths gram substance.

The solubility of the "yellow precipitate" just as it is precipitated in ordinary work along with the salts carried down with it was also determined in the wash solution by allowing 200 cc. of them to stand in contact with the precipitate for one-half and one hour, respectively, after stirring thoroughly. The precipitates settled completely and quickly in this way. In none of these washes could more than a trace of phosphoric acid be found. Again all the washings (3600 cc.) from six determinations of phosphoric acid in two phosphate solutions (a 3.30 per cent. and a 19.83 per cent.) were combined, evaporated down and the phosphoric acid in them determined by the gravimetric method, when 0.38 milligrams phosphorus pentoxide was found, corresponding to a plus correction of 0.03 per cent. on basis of two-tenths gram substance. A similar result was obtained from the washings from eight determinations on the same samples.

These results indicate that while the wash solutions used in the volumetric method have marked solvent power for molybdic acid, they have practically no solvent action on ammonium phosphomolybdate, and that a correction for ordinary work at least is not necessary. There is danger, however, of mechanical loss. The precipitate is first washed by decantation with dilute nitric acid and potassium nitrate, and afterwards with water to remove nitric acid. In this after washing, when all the salts have been removed from the precipitate and as much as 600 or 700 cc. has been used, the precipitate begins to pass through the filter mechanically and settle to the bottom of the receptacle. We have not, however, found it necessary to wash with more than 300 cc. of water in our present manipulation of the method. We consider that 500 or 600 cc. of water may be used without this loss, but the filtrate should be closely observed when the washing goes beyond this amount.

INVESTIGATION OF MOLYBDIC SOLUTIONS.

Besides the comparison of the aqueous molybdate of Pemberton with the official molybdic solution recorded in my last year's work,[1] nine other molybdic solutions of different formulas, in-

[1] This Journal, 16, 769.

cluding five or six of those most highly recommended by different analysts, and the remainder of our own making, have been tried. The formulas of these solutions need not be given. They varied quite widely in the proportions of molybdic acid to free nitric acid and ammonium nitrate as well as in degrees of concentration.

Without going into a detailed discussion of the results and the advantages possessed by the different molybdic solutions for different purposes, we will merely state that we found the official molybdic solution of the following formula and made by dissolving 100 grams of molybdic acid in 400 grams, or 417 cc., of ammonia of 0.96 sp. gr., and pouring this into 1250 cc., or 1500 grams nitric acid of 1.20 sp. gr. to be the one best suited to the volumetric method for very small quantities of phosphoric acid, one per cent or less. For percentages larger than one, the foregoing solution with the addition of eighty extra cc. of 1.42 sp. gr. nitric acid, or five cc. to each 100 cc. of official molybdic solution was found to be the best. 100 cc. of this latter solution contains practically six grams of molybdic acid, four and six-tenths grams ammonium nitrate, and thirty-five cc. free nitric acid of 1.42 sp. gr., which is about the largest quantity of free nitric acid in proportion to molybdic acid that can be used in a molybdic solution not to interfere with quick and ready precipitation of phosphoric acid. When a larger proportion of free nitric acid is in the solution, precipitation of phosphoric acid is either incomplete or is very materially retarded. This modified official molybdic solution, containing the large amount of nitric acid, can be readily used for all percentages of phosphoric acid, but it contains rather too much free nitric acid to allow of the quickest precipitation of very small quantities, but by extending the time of precipitation to eight to ten minutes it will be found to be complete even when very small amounts are present. The judgment and manipulation of the analyst will, however, be the best guide as to whether he will employ the solution containing the larger amount of nitric acid for all percentages, or whether he will only use it for those above one or so, and use the regular official solution for less amounts.

EFFECT OF ORGANIC ACIDS IN PREVENTING DEPOSITION OF MOLYBDIC ACID.

Jüptner[1] has successfully used two-tenths to six grams of tartaric acid per 100 cc. of molybdic solution for preventing the deposition of molybdic acid in the determination of phosphorus in steel. One to four grams of citric acid to 100 cc. of the two foregoing molybdic solutions were employed in the hope of accomplishing the same object. When three and four grams of citric acid were used precipitation was not complete in fifteen or twenty minutes, and with smaller quantities (one, one and five-tenths, and two grams) precipitation was complete in a reasonable length of time (seven to fifteen minutes), but the results at best showed no advantage over those obtained on the same samples with molybdic solutions without the presence of citric acid.

ACIDITY OF AMMONIUM PHOSPHOMOLYBDATE.

Hundeshagen[2] has stated that it required twenty-three molecules of Na_2CO_3 (or of Na_2O) to neutralize the ammonium phosphomolybdate containing one molecule of phosphorus pentoxide.

H. Pemberton, Jr.,[3] working upon a solution of chemically pure disodium hydrogen phosphate, found that 23.2 molecules of sodium carbonate were necessary to neutralize the ammonium phosphomolybdate containing one phosphorus pentoxide molecule; a second determination,[4] however, working in the same way, gave him 22.99 molecules.

In the course of my work upon the volumetric method, I have determined the acidity of ammonium phosphomolybdate in two ways. First, by finding the amount of alkali necessary to neutralize the ammonium phosphomolybdate formed from a given amount of phosphate. This was done by dissolving ten grams of chemically pure disodium hydrogen phosphate in a liter of water, carefully measuring out twenty cc. portions, precipitating with molybdic solution, washing thoroughly according to our practice in the volumetric method, and titrating with alkali.

The results obtained are as follows:

[1] Abs. Expt. Sta. Record, **6**, 610.
[2] *Ztschr. anal. Chem.*, **28**, 141–172.
[3] This Journal, **15**, 382.
[4] *Ibid*, **16**, 278.

	Cc. of phosphate solution used.	Equaling grams $Na_2HPO_4.12H_2O$.	Equaling grams P_2O_5.	Cc. KOH solution required to neutralize phosphomolybdate formed.
1	20	0.20000	0.039652	39.80
2	20	0.20000	0.039652	39.80
3	20	0.20000	0.039652	39.80

Dividing the weight of phosphorus pentoxide by the number of cc. alkali required to neutralize the phosphomolybdate formed, we find that 100 cc. alkali has neutralized an amount of ammonium phosphomolybdate containing 99.628 milligrams phosphorus pentoxide.

The alkali was now titrated against semi-normal hydrochloric acid, carefully standardized by silver nitrate to contain 18.2285 grams hydrochloric acid per liter. 100 cc. of the alkali equaled 64.5 cc. of the semi-normal acid, which contained 1175.74 milligrams hydrochloric acid, which in turn equals 1519.3 milligrams potash, or 2228.6 milligrams potassium carbonate. Therefore, 1519.3 milligrams potash equals 99.628 milligrams phosphorus pentoxide in the yellow precipitate. Dividing each of these by its molecular weight, we obtain

for phosphorus pentoxide $\frac{99.628}{142.06} = 0.7013.$

for potash $\frac{1519.3}{94.22} = 16.125.$

Then, $P_2O_5 : K_2O = 0.7013 : 16.125 = 1 : 22.993.$

The relation between standard alkali and phosphorus pentoxide in the "yellow precipitate" was now determined by preparing pure phosphomolybdates by precipitating sodium phosphate with a deficient quantity of molybdic solution, pouring off the filtrate, washing by decantation, first with dilute nitric acid and then with water, and drying at 130° to 150° C. to constant weight. These phosphomolybdates contained 2.232 per cent. nitrogen (average of seven analyses), the theory being 2.238; and 1.645 per cent. phosphorus, the theory being 1.651. The following results were obtained by titrating a portion of three of these:

	Grams ammonium phosphomolybdate used.	Cc. standard alkali required to neutralize.
1	1.2322	46.55
2	0.8050	30.45
3	0.7955	30.10
Total	2.8327	107.10

One hundred cc. of alkali has, therefore, neutralized 2.6449 grams of ammonium phosphomolybdate, which multiplied by 3.783, (the per cent. of phosphorus pentoxide in the "yellow precipitate") gives 100.05 milligrams phosphorus pentoxide in 2.6449 grams of this salt, and which corresponds to 100 cc. of the alkali used.

One hundred cc. of this alkali was found as before to equal 64.74 cc. semi-normal hydrochloric acid, which contains 1180.14 milligrams hydrochloric acid, and which in turn equals 2237.08 milligrams of potassium carbonate. Therefore 2237.08 milligrams potassium carbonate equals the 100.05 milligrams of phosphorus pentoxide contained in the 2.6449 grams of "yellow precipitate."

Dividing by molecular weights, there is found

for phosphorus pentoxide $\frac{100.05}{142.06} = 0.7042.$

for potassium carbonate $\frac{2237.08}{138.22} = 16.185.$

Therefore, $P_2O_5 : K_2CO_3 = 0.7042 : 16.185 = 1 : 22.983.$

It has, therefore, required practically twenty-three molecules of potassium carbonate (or of potash) to neutralize an amount of ammonium phosphomolybdate ($6NH_4.P_2O_5.24MoO_3$) containing one molecule of phosphorus pentoxide. On this basis, one cc. of a standard alkali containing 18.17106 grams of potassium hydroxide to the liter would equal one milligram phosphorus pentoxide. 100 cc. of this solution will neutralize 32.38 cc. of normal acid; and either the acid or alkali to be used in the volumetric method can be made by diluting 323.8 cc. of corresponding normal solution to one liter.

The above calculations are based upon the following atomic weights:

Sodium.....23.05	Oxygen.. ...16.	Chlorine.....35.45
Hydrogen ... 1.007	Potassium ...39.11	Molybdenum 96.
Phosphorus..31.03	Carbon .....12.	Nitrogen 14.03

RESULTS BY VOLUMETRIC METHOD AS NOW WORKED IN THIS LABORATORY COMPARED WITH GRAVIMETRIC RESULTS.

The writer was again reporter of the Association of Official Agricultural Chemists on methods for determining phosphoric acid for 1894–95, and the foregoing investigation was made with a view of setting the method in better shape for trial by this

association and for perfecting it, if possible, for use in this laboratory. The method was accordingly changed quite materially, redescribed to accord with results of the preceding work, and sent out to various official and other chemists for trial with three samples upon which to conduct the work. These samples were :

No. 1 was a chemically pure disodium hydrogen phosphate solution containing ten grams of the salt per liter, the theoretical percentage of phosphorus pentoxide in it being 19.826.

No. 2 was solution No. 1 diluted with five parts of water, and therefore contained the equivalent of 3.304 per cent. phosphorus pentoxide in fifty cc.

No. 3 was a mixed fertilizer.

The results obtained in this laboratory on these samples by gravimetric and volumetric methods and presented to the association are brought together in Table II.

These results are what, I deem, may be termed *most excellent.*

It may not be out of place here to state also that the results of nine other chemists on these same samples, including thirty-one determinations on No. 1 and thirty-three on No. 2, excluding three results, are as good as those in the table. Seventy-three per cent. of all the results of thirteen chemists on sample No. 1 are within 0.05 per cent. of the theory, and ninety-three per cent. within one-tenth per cent., there being only three results varying more than one-tenth. On sample No. 2 eighty-five per cent. of all results are within 0.05 per cent. of the theory and all are within one-tenth.

This summary of results of members of the Association of Official Agricultural Chemists by the volumetric method are in rather marked contrast to the results of this and all previous years by the official gravimetric method, and also to the results by the volumetric method as worked last year. The results last year by the volumetric method were considered on the whole as encouraging, while the method as worked this year has given extremely good results in all hands.

The volumetric and gravimetric methods have been compared in this laboratory upon quite a variety of phosphates and fertilizer materials of varying percentages. The results follow in Table III.

TABLE II. TOTAL PHOSPHORIC ACID BY GRAVIMETRIC AND VOLUMETRIC METHODS.

Analyst.	Sample No. 1. Methods and washings. Official gravimetric.	Volumetric.	Washing water.	Difference + greater — less than gravimetric.	Sample No. 2. Methods and washings. Official gravimetric.	Volumetric.	Washing water.	Difference + greater — less than gravimetric.	Sample No. 3. Methods and washings. Official gravimetric.	Volumetric.	Washing water.	Difference + greater — less than gravimetric.
	Per cent.	Per cent.	cc.	Per cent.	Per cent.	Per cent.	cc.	Per cent.	Per cent.	Per cent.	cc.	Per cent.
W. M. Allen	19.93	19.81	275		3.38	3.28	265		12.50	12.32	275	
	19.97	19.84	250	—.11	3.39	3.27	300		12.59	12.39	300	—.17
	19.96	19.88	285		....	3.27	275	—.109	....	12.39	350	
	....	....	....		....	3.29	275		....	....	....	
	....	....	....		....	3.28	300		....	....	....	
	....	....	....		....	3.27	275		....	....	....	
C. B. Williams	19.91	19.80	220		....	3.32	210		....	12.32	240	
	....	19.85	230	—.073	....	3.32	220		....	12.32	270	
	....	19.85	250		....	3.32	205		...	12.32	235	
	....	19.85	250		....	3.32	220		....	12.42	220	
F. B. Carpenter	19.83	19.85	275	+.03	3.38	3.32	250	—.006	12.43	12.39	250	+.0
	....	19.87	275		3.33	3.34	250		12.37	12.43	250	
B. W. Kilgore	19.96	19.83	280		3.38	3.32	300		....	12.40	225	
	19.89	19.83	280	—.12	3.39	3.31	200	—.083	....	12.40	190	
	20.00	19.83	250		3.40	3.30	200		....	12.37	200	
	....	....	....		....	3.30	210		....	12.37	250	
Average	19.93	19.84	....	....	3.38	3.302	....	....	12.475	12.37	....	....
Theory	19.826	19.826	....	....	3.304	3.304	....	....	....	....	....	....
Variation of lowest result from theory	0.004	0.026	....	....	0.026	0.034	....	....	....	....	....	....
Variation of highest result from theory	0.174	0.054	....	....	0.096	0.034	....	....	....	....	....	....

TABLE III. DETERMINATIONS OF PHOSPHORIC ACID IN VARIOUS MATERIALS BY VOLUMETRIC AND GRAVIMETRIC METHODS.

Material.	Number.	Gravimetric Method.	Volumetric method.	Washing water.	Difference greater + less — than gravimetric method.
C. B. Williams, Analyst.....		Per cent.	Per cent.	cc.	Per cent.
Cottonseed meal	1	0.08	0.08	130	.00
	2	0.37	0.35	160	—.02
	3	1.32	1.28	100	—.04
	4	1.50	1.45	240	—.05
	5	0.88	0.79	215	—.09
	6	0.65	0.61	250	—.04
Fertilizers and fertilizing materials	7	0.64	0.61	250	—.03
	8	1.27	1.25	240	—.02
	9	1.29	1.25	250	—.04
	10	4.96	4.95	155	—.01
	11	4.98	4.92	180	—.06
	12	11.80	11.80	120	.00
	13	11.58	11.45	250	—.13
	14	9.77	9.80	240	+.03
	15	10.04	10.05	220	+.01
W. M. Allen, Analyst.....					
Mixed fertilizer	1	11.58	11.45	250	
			11.48	260	—.09
			11.53	280	
" "	2	9.54	9.50	275	—.02
			9.53	285	
B. W. Kilgore, Analyst.....					
Mixed fertilizer	1	9.77	9.76	275	.00
		9.75			
" "	2	9.03	8.96	210	—.07
	3	10.67	10.66	220	—.01
	4	11.58	11.60	275	+.02
	5	9.77	9.76	275	—.01
	6	10.04	10.01	275	—.03
	7	9.54	9.48	275	—.06
Acid phosphate	8	15.49	15.42	275	—.07
Insoluble	9	2.57	2.60	230	+.03
Reporter's sample No. 1[1]	10	19.96	19.88	260	—.05
		19.89	19.88	260	

Material.	Number.	Gravimetric method.	Volumetric method.	Washing water.	Difference greater + less — than gravimetric method
		Per cent.	Per cent.	cc.	Per cent.
Fertilizers and fertilizing materials	16	9.54	9.45	260	—.09
	17	10.72	10.65	270	+.07
	18	6.46	6.40	230	—.06
	19	6.55	6.60	250	+.05
	20	5.45	5.50	290	+.05
	21	6.52	6.60	280	+.08
	22	7.47	7.44	250	+.03
			7.44	230	
	23	7.42	7.44	240	
			7.48	230	+.04
	24	17.55	17.52	260	
		17.55	17.52	260	—.03
Florida phosphate	25	38.12	37.80	260	
			37.84	260	—.30
Acid phosphate	26	15.49	15.35	290	—.14
" "	27	13.27	13.15	280	—.12
Acid phosphate	3	15.49	15.47	250	
			15.43	275	—.04
Mixed fertilizer	4	10.72	10.70	260	
" "			10.67	275	—.03
	5		15.35		
Mixed fertilizer	11	10.72	10.68	275	—.04
Acid phosphate	12	13.27	13.21	275	—.06
Mixed fertilizer	13	11.71	11.63	275	—.08
" "	14	11.88	11.75	275	—.13
" "	15	9.43	9.38	250	—.05
" "	16	9.71	9.80	230	+.09
Bone meal	17	10.38	10.30	250	—.08
Acid phosphate	18	20.53	20.48	210	—.05
" "	19	15.02	15.10	220	+.08
Reporter's sample No. 2[2]	20	3.38	3.30	220	—.08
		3.39	3.31	220	
Reporter's sample No. 3	21		12.43	260	
			12.43	260	
			12.45	260	

[1] C. P. $Na_2HPO_4.12H_2O$ = 19.836 per cent. P_2O_5.

These volumetric results show close agreement with the gravimetric ones, though they are generally slightly lower than the latter. When we observe the close agreement of duplicate results by the volumetric method and remember the tendency of the molybdate method to give high results, we have ground for believing that the volumetric results are more nearly correct.

RESULTS ON A HIGH GRADE PHOSPHATE.

To see how the volumetric method would work on a very high percentage phosphate and to see how the results by the two methods would compare on it, a high grade Florida phosphate was submitted to analysis, with the following results:

	C. B. Williams, analyst. per cent.	B. W. Kilgore, analyst. per cent.
Gravimetric method	38.12	
Volumetric method	37.80	37.80
	37.84	37.88
Less by volumetric method	0.30	

The foregoing results by the volumetric method, our work upon it, and experience with it generally lead us to consider it a more accurate and reliable method than the molybdate-magnesia method. Since the change of temperature of precipitation, precipitating reagent, wash solutions, and manner of washing from what they were in the Pemberton method, the difficulty of getting occasionally very high results in the midst of good ones, and which did so much to destroy faith in the method, seems not to occur under the new method of procedure. The accuracy, reliability and rapidity of the method, a man being able to make, we think, twice as many determinations by it as by the gravimetric method, causes us to feel that the large amount of time which we have put upon the method has been well spent and will soon repay us in the saving of time on this class of work in our own laboratory, to say nothing of the service it may be to others having, as we do, large amounts of phosphoric acid work to do.

I am indebted to Messrs. C. B. Williams and W. M. Allen for assistance in carrying out the foregoing work.

The method, as we have found it to give the best results, may be described as follows:

Weigh two grams of substance and make solution by one of the following methods: (1) Evaporate with five cc. of magnesium nitrate solution, ignite, and dissolve in hydrochloric acid. This is for organic materials. (2) Dissolve in thirty cc. concentrated nitric acid with a small quantity of hydrochloric acid. (3) Add thirty cc. concentrated hydrochloric acid, heat, and add cautiously in small quantities at a time about five-tenths gram of finely pulverized potassium chlorate. These (2 and 3) are for ordinary phosphates and fertilizers. (4) Dissolve in fifteen to thirty cc. of strong hydrochloric acid and five to ten cc. of nitric. This is for phosphates containing much iron and aluminum. Method 2 is preferred when these acids are a suitable solvent for the material. Make up to 200 cc. (or any other convenient volume), measure out twenty cc. for totals, or for percentages above five or six; and forty cc. for insolubles, or for percentages below five or six, corresponding to two-tenths and four-tenths gram substance respectively, add about five cc. concentrated nitric acid, when method 2 for solution has been used and about ten cc. when method 1, 3, or 4 has been used. Now add ammonia until precipitate just begins to form, dilute high percentage solutions to about 100 cc., and low percentage ones to from sixty to seventy-five cc., digest in water-bath at 60° to 65° C., and after filtering the molybdic solution to be used in this method, precipitate, not using any greater excess of molybdic solution than is necessary to insure complete precipitation; let stand in bath six minutes from the time the molybdate is added, and filter as quickly as possible upon a three-inch Hirsch funnel, whose perforations are covered with a disk of soft filter-paper, or in a Gooch crucible with one or two pieces of filter-paper slightly larger than the bottom of the crucible, tightly pressed against the bottom of the crucible, or upon a filter made by putting a platinum cone or disk, well filled with holes, into a three-inch funnel and covering with coarse asbestos, using the pump in all cases. Filter-paper may be used, but the other filters in the order named are much to be preferred.

It is *especially urged* that the three-inch Hirsch funnel be used where possible, as it permits of rapid filtration and easy and thorough washing. Wash the precipitate twice by decantation

with dilute nitric acid, using fifty to seventy-five cc. each time and agitating thoroughly, once by decantation with the same amount of three per cent. potassium or ammonium nitrate solution, then on the filter and with 200 to 500 cc. water, (250 cc. is usually enough) or until no longer acid. Now wash the precipitate with filter back into the beaker, titrate with potassium hydroxide, and back with nitric acid, using phenolphthalein as indicator and adding acid until color disappears.

In washing by decantation, if the precipitate is allowed to settle completely each time, no trouble will be experienced in the after washing.

Where the phosphoric acid is below one per cent., the precipitation is not so rapid as in larger percentages and may require eight or even ten minutes to be complete.

REAGENTS TO BE USED IN THE VOLUMETRIC METHOD.

Molybdic Solution.—Dissolve 100 grams of molybdic acid in 400 grams, or 417 cc. of ammonia, sp. gr. 0.96, and pour the solution thus obtained into 1500 grams, or 1250 cc. of nitric acid, sp. gr. 1.20, and add eighty cc. nitric acid, sp. gr. 1.42. Or to each 100 cc. of the official molybdic solution (the above formula without the eighty cc. nitric acid), add five cc. 1.42 sp. gr. nitric acid. This solution should be filtered each time before using.

Dilute Nitric Acid Wash.—Dilute 100 cc. 1.42 sp. gr. nitric acid to one liter.

Potassium or Ammonium Nitrate Wash.—Dissolve three grams of either in 100 cc. of water.

Alcoholic Solution of Phenolphthalien.—100 cc. to one gram.

Standard Potassium Hydroxide.—This solution should contain 18.17106 grams potassium hydroxide to the liter. One cc. of this solution equals one milligram phosphorus pentoxide (one per cent. phosphorus pentoxide on basis of one-tenth gram substance) 100 cc. of it will neutralize 32.38 cc. normal acid, and can be made by diluting 323.81 cc. of normal potassium hydroxide, which has been freed from carbonates by barium hydroxide to one liter.

Standard Nitric Acid of same, or one-half, the strength of alkali. Hydrochloric or sulphuric acid will do.

NORTH CAROLINA EXPERIMENT STATION,
RALEIGH, N. C.

THE RELATIONSHIP OF THE HEAT OF VAPORIZATION OF GASES TO THEIR DENSITY AND ALSO TO THEIR BOILING-POINT.

By Wm. L. Dudley.

Received September 27, 1895.

IN studying the heat of vaporization or latent heat of various gases it soon became apparent that this constant bore an interesting relationship to their density and boiling-point. To trace out this relationship I have endeavored to obtain the latest and best latent heat determinations, as well as the specific gravity of the liquids at the boiling-point. Accurate data of this kind are scarce, and there are few homologous series in which these constants have been determined for many members. However, I have obtained a sufficient number of trustworthy determinations to show some results, which seem to be worth recording.

The amount of heat absorbed by one cc. of vapor (reduced to 0° and 760 mm. pressure) in the passage of the liquid to the gaseous state, is taken as the standard for comparison. This constant is found by the formula

$$L = \frac{H \times w}{W}.$$

where L = the heat of vaporization in one cc. of vapor,

W = the weight of one cc. of the liquid at its boiling-point,

H = the heat of vaporization,

and w = the weight of one cc. of the vapor at 0° and 760 mm. pressure.

Until the latent heat researches made by R. Schiff[1] these constants were determined without any special reference to the relationship of the compounds to one another, and, therefore, not many series can be found complete enough to make a comparison. I believe, however, that I have gathered the data quite completely and I give in this paper all the series in which the data are complete for as many as three members.

In the following tables the columns marked

[1] *Ann. Chem.* (Liebig), **234**, 338, *1886*.

D = the vapor density,
B. P. = Boiling-point in absolute temperature,
S. G. = Specific gravity at the boiling-point,
H. V. = Heat of vaporization in calories,
V = Volume of vapor, in cubic centimeters (reduced to 0° and 760 mm. pressure), produced from one cc. of liquid at the boiling-point.
L = Heat of vaporization in a unit of volume (one cc.) of gas reduced to 0° and 760 mm. pressure.

The specific gravity of liquids at the boiling-point is taken from Clarke's tables of "Constants of Nature," where the references are fully given. The boiling-point is obtained from Carnelley's tables.

I will first show the results obtained from some of the fatty acids and their alkyl compounds.

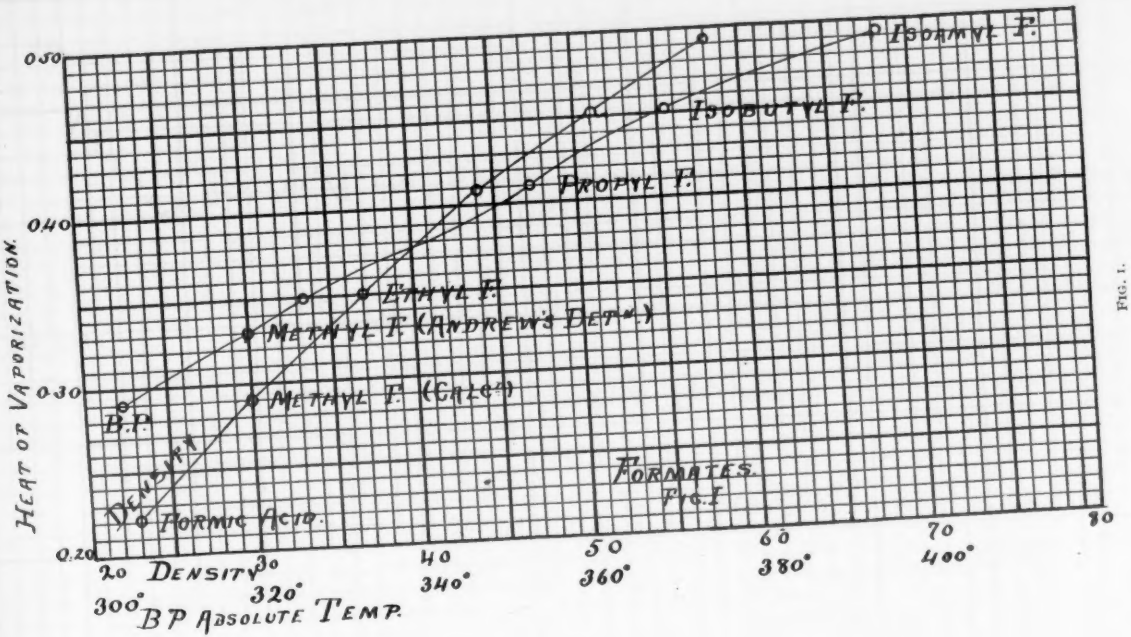
FORMATES.

Name.	Formula.	D.	B. P.	S. G.	H. V.	V.	L.
Formic acid	$HCHO_2$	23	373.8°	1.1175	120.72[1]	542.26	0.2226
Methyl formate	CH_3CHO_2	30	305.3°	0.95196	117.10[2] 102.70[3]	354.15	0.3306 0.2900
Ethyl formate	$C_2H_5CHO_2$	37	326.5°	0.86667	92.15[4]	263.36	0.3499
Propyl formate	$C_3H_7CHO_2$	44	354.2°	0.82146	85.25[4]	208.37	0.4091
Isobutyl formate	$C_4H_9CHO_2$	51	371.0°	0.7784	77.0[4]	170.34	0.4520
Isoamyl formate	$C_5H_{11}CHO_2$	58	397.0°	0.7554	71.65[4]	145.35	0.4929

Fig. 1 represents the curves of the formates, the density and boiling-point curves being shown on the same sheet. In all cases the corresponding acids fall in line in the density curves but not in the boiling-point curves. The acids, however, form both density and boiling-point curves of their own, as will be shown later on.

It will be seen from Fig. 1 that the heat of vaporization per unit of volume (H. V.) of methyl formate obtained from the result of Andrews' determination is too high. To conform to the curve it should be 0.2900 which would give 102.70 as the heat of vaporization (H. V.) instead of 117.10 as given by Andrews, whose determination has never been verified. But

[1] Favre and Silberman: *Ann. chim. phys.* [3], **37**, 464–470.
[2] Andrews: Chem. Soc. Quar. J., **1**, 27.
[3] Calculated from the data furnished by the curves shown in this paper.
[4] Schiff: *Ann. Chem.* (Liebig), **234**, 338.


Isoamyl F.
Isobutyl F.
Propyl F.
Ethyl F.
Methyl F. (Andrew's Det.)
Methyl F. (Calc.)
B.P.
Formic Acid.
Formates.
Fig. 1.
Heat of Vaporization.
0.50
0.40
0.30
0.20
20
30
40
50
60
70
80
Density
300°
320°
340°
360°
380°
400°
B.P. Absolute Temp.

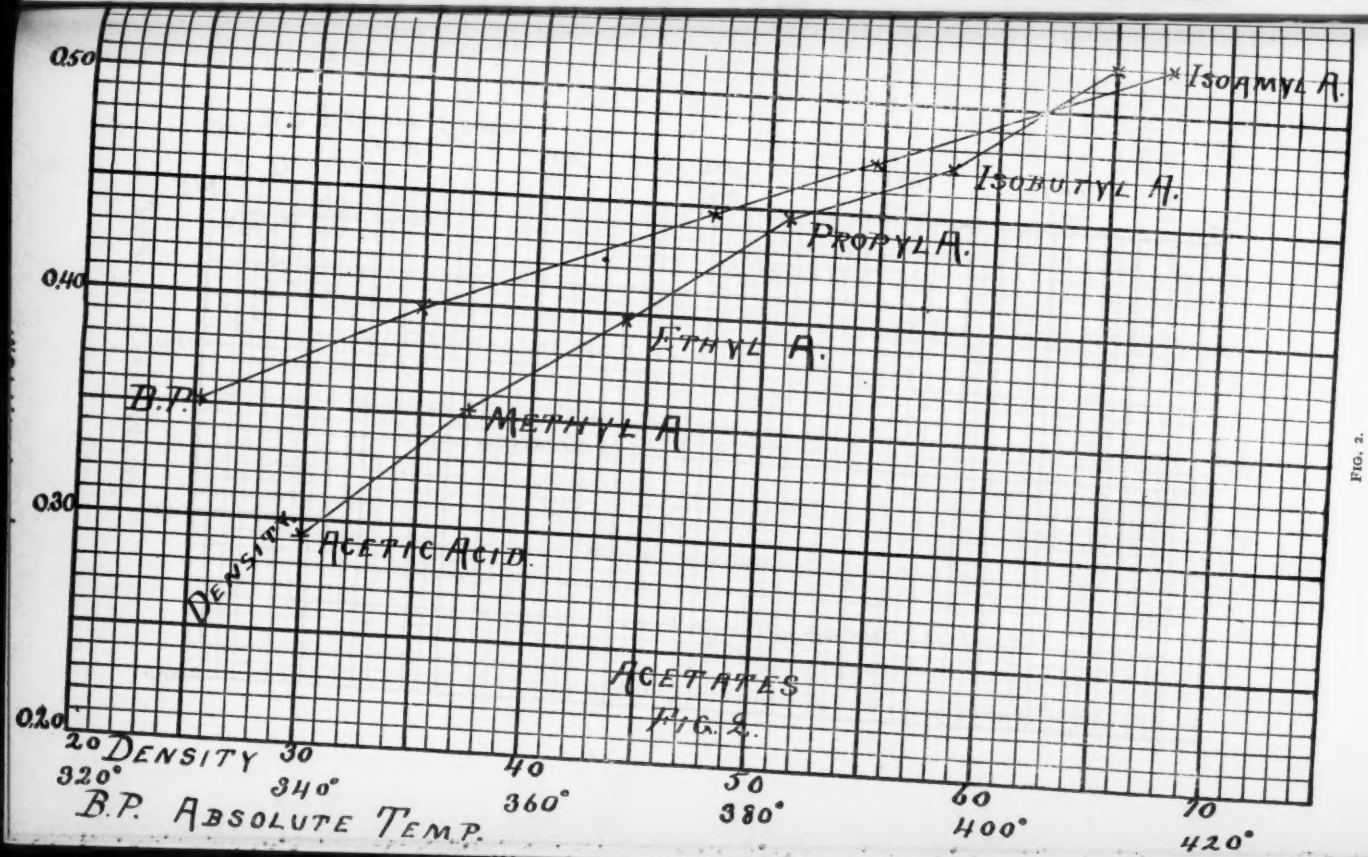

0.50
0.40
0.30
0.20
Isoamyl A.
Isobutyl A.
Propyl A.
Ethyl A.
Methyl A
B.P.
Density
Acetic Acid.
20
30
40
50
60
70
320°
340°
360°
380°
400°
420°
B.P. Absolute Temp.
Acetates
Fig. 2.

Fig. 2.

since many of Andrews' determinations have been found by later investigators to be considerably too high, it is reasonable to suppose under the circumstances that this one is too high also. To substantiate this I will give the following instances, which may be cited from determinations made by Andrews and Schiff:

Methyl acetate	Andrews,	110.20
	Schiff,	93.90–94.0
Ethyl acetate	Andrews,	92.68
	Schiff,	83.0–83.1–83.1
Ethyl formate	Andrews,	105.30
	Schiff,	92.2–92.1

ACETATES.

Name.	Formula.	D.	B. P.	S. G.	H. V.	V.	L.
Acetic acid	$HC_2H_3O_2$	30	391.1°	0.9372	101.91[1]	348.66	0.2923
Methyl acetate	$CH_3C_2H_3O_2$	37	330.3°	0.8808	93.95[2]	265.68	0.3536
Ethyl acetate	$C_2H_5C_2H_3O_2$	44	350.0°	0.82673	83.1[3]	209.70	0.3961
Propyl acetate	$C_3H_7C_2H_3O_2$	51	375.3°	0.7917	77.3[2]	173.25	0.4462
Isobutyl acetate	$C_4H_9C_2H_3O_2$	58	389.8°	0.7708	69.9[2]	148.32	0.4713
Isoamyl acetate	$C_5H_{11}C_2H_3O_2$	65	415.0°	0.74295	66.35[2]	127.56	0.5201

The acetates form very good curves, as will be seen in Fig. 2. The boiling-point curve is almost a straight line. It has been shown above that Schiff's determinations of the heats of vaporization (H. V.) of methyl and ethyl acetates are much lower than those of Andrews. Favre and Silberman's determination gives a number for ethyl acetate much higher than that of either of the other investigators, it being 105.8. The results of Schiff are taken as being more nearly correct.

PROPIONATES.

Name.	Formula.	D.	B. P.	S. G.	H. V.	V.	L.
Propionic acid	$H.C_3H_5O_2$	37	413.7°	0.8589	90.42[3]	259.08	0.3490
Methyl propionate	$CH_3.C_3H_5O_2$	44	353.0°	0.836798	84.15[4]	212.25	0.3965
Ethyl "	$C_2H_5.C_3H_5O_2$	51	371.7°	0.7962	77.1[4]	174.64	0.4415
Propyl "	$C_3H_7.C_3H_5O_2$	58	395.6°	0.76815	71.5[4]	147.81	0.4832
Isobutyl "	$C_4H_9.C_3H_5O_2$	65	409.8°	0.74424	66.0[4]	127.78	0.5165
Isoamyl "	$C_5H_{11}.C_3H_5O_2$	72	433.5°	0.7295	63.05[4]	113.08	0.5576

The curves representing the propionates are shown in Fig. 3, and it will be seen that they are quite regular. The heat of vaporization (H. V.) of propionic acid has never been deter-

[1] Favre and Silberman: *Ann. chim. phys.* [3], **37**, 464–470.

[2] Schiff: *Ann. Chem.* (Liebig), **234**, 338.

[3] Calculated by the data furnished by the curves shown in this paper.

[4] Schiff: *Ann Chem.* (Liebig), **234**, 338.

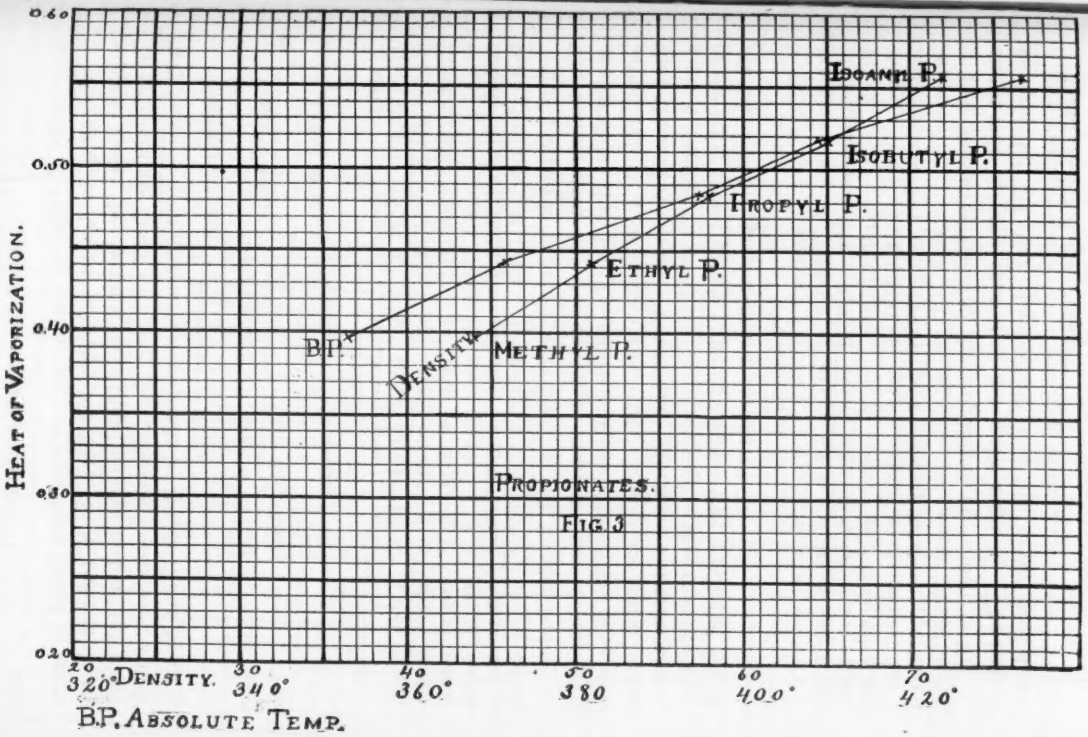

0.60
0.50
0.40
0.30
0.20
HEAT OF VAPORIZATION.
ISOAMYL P.
ISOBUTYL P.
PROPYL P.
ETHYL P.
METHYL P.
B.P.
DENSITY.
PROPIONATES.
20
30
40
50
60
70
320°
340°
360°
380
400°
420°
DENSITY.
B.P. ABSOLUTE TEMP.

FIG. 3.

FIG. 3

mined; but according to the density curve of the propionates, its heat per unit of volume of vapor (L.) should be 0.3490, which would give for the heat of vaporization (H. V.) the number 90.42.

BUTYRATES.

Name.	Formula.	D.	B. P.	S. G.	H. V.	V.	L.
Butyric acid	$H.C_4H_7O_2$	44	435.5°	0.8120	114.67[1] 82.79[2]	205.96	0.5567 0.4020
Methyl butyrates	$CH_3C_4H_7O_2$	51	375.3°	0.80261	87.93[1] 77.25	175.64	0.4972 0.4398
Ethyl "	$C_2H_5C_4H_7O_2$	58	392.0°	0.7694	71.5[3]	148.05	0.4829
Propyl "	$C_3H_7C_4H_7O_2$	65	416.4°	0.745694	66.2[3]	128.03	0.5170
Isobutyl "	$C_4H_9C_4H_7O_2$	72	429.7°	0.7163	61.9[3]	111.03	0.5575
Isoamyl "	$C_5H_{11}C_4H_7O_2$	79	451.0°	0.71148	59.4[3]	100.51	0.5910

The curves of the butyrates are shown in Fig. 4. The density curve is almost a straight line, while the boiling-point curve breaks badly at propyl butyrate. This would indicate that its boiling-point, as determined, is too high and should be 408° (absolute temperature) instead of 416.4°, as determined by Linneman, which is given the preference by Carnelley over other determinations. The recorded results of the determinations of the boiling-point of propyl butyrate are as follows:

144.3° C.	Pawlewski.
143.42° C.	Linneman.
142.7° C.	Elsässer.
139°–141° C.	Chancel.
137.25° (765)	Pierre and Puchot.

The last result would agree very well with that deduced from the curve, *viz.*, 135° C.

The heat of vaporization (H. V.) of butyric acid has only been determined by Favre and Silberman. Their result is 114.67 cal., which is probably too high. It gives the heat per unit of volume (L.) 0.5567, which throws it entirely out of the curve shown in Fig. 4, according to which the number should be about 0.4020; this would give 82.79 cal. as the heat of vaporization (H. V.) of butyric acid. As will be seen in the table above Favre and Silberman's result for methyl butyrate is much higher than Schiff's.

[1] Favre and Silberman: *Ann. chim. phys.* [3], **37**, 464-470.
[2] Calculated by the data furnished by the curves shown in this paper.
[3] Schiff: *Ann. Chem.* (Liebig), **234**, 338.

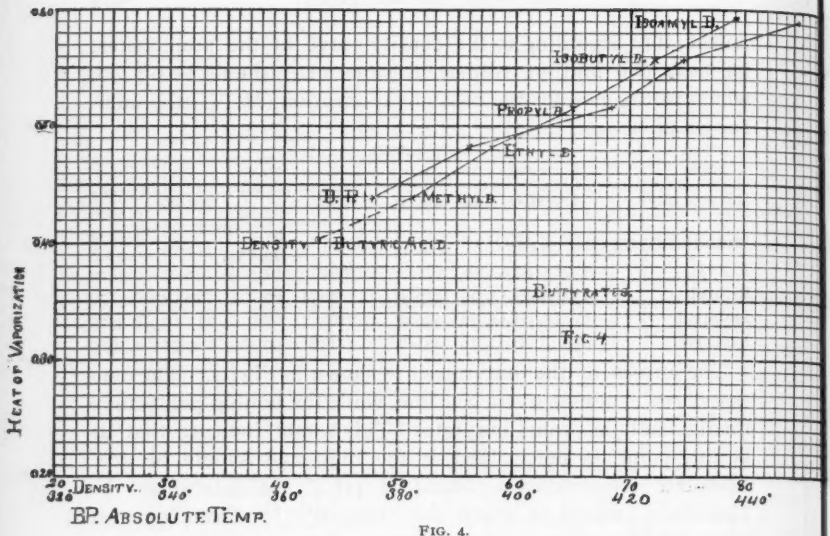

Isoamyl B.
Isobutyl B.
Propyl B.
Ethyl B.
B.P.
Methyl B.
Density
Butyric Acid.
Butyrates.
Fig. 4
Heat of Vaporization
Density
B.P. Absolute Temp.

Fig. 4.

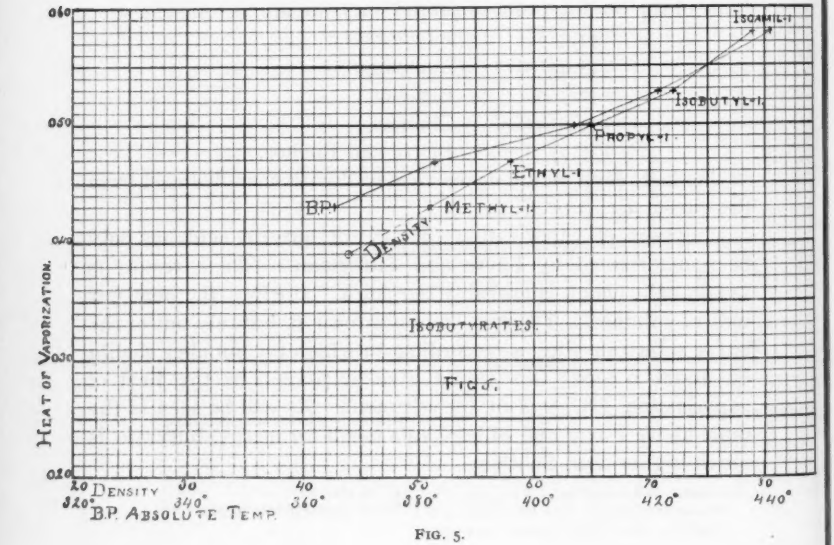

Isoamyl I.
Isobutyl I.
Propyl I.
Ethyl I.
B.P.
Methyl I.
Density
Isobutyrates.
Fig. 5.
Heat of Vaporization.
Density
B.P. Absolute Temp.

Fig. 5.

ISOBUTYRATES.

Name.	Formula.	D.	B. P.	S. G.	H. V.	V.	L.
Isobutyric acid	$H.C_4H_7O_2$	44	428.5°	0.8054	76.67[1]	204.29	0.3900
Methyl isobutyrate	$CH_3.C_4H_7O_2$	51	365.5°	0.80397	75.5[2]	175.93	0.4291
Ethyl "	$C_2H_5.C_4H_7O_2$	58	383.0°	0.7681	69.2[2]	147.80	0.4682
Propyl "	$C_3H_7.C_4H_7O_2$	65	407.0°	0.74647	63.9[2]	128.17	0.4985
Isobutyl "	$C_4H_9.C_4H_7O_2$	72	421.6°	0.73281	59.95[2]	113.59	0.5278
Isoamyl "	$C_5H_{11}C_4H_7O_2$	79	441.0°	0.70662	57.65[2]	99.82	0.5775

The isobutyrate curves (Fig. 5) seem to indicate that the heats of vaporization (H.V.) of the propyl and isobutyl isobutyric rates as determined are a trifle too low. From the density curve it will be seen that the heat per unit of volume (L.) of isobutyric acid should be 0.3900 which would give 76.67 cal. for the heat of vaporization (H. V.). No determination of this constant has been recorded.

VALERATES.

Name.	Formula.	D.	B. P.	S. G.	H. V.	V.	L.
Valeric acid	$H.C_5H_9O_2$	51	458.4°	0.7828	103.52[3] 73.83[4]	171.30	0.6042 0.4310
Methyl valerate	$CH_3C_5H_9O_2$	58	389.3°	0.77518	69.95[5]	149.16	0.4684
Ethyl "	$C_2H_5C_5H_9O_2$	65	407.0°	0.74764	64.65[5]	128.37	0.5036
Propyl "	$C_3H_7C_5H_9O_2$	72	428.5°	0.727405	61.2[5]	112.75	0.5427
Isobutyl "	$C_4H_9C_5H_9O_2$	79	442.0°	0.70549	57.85[5]	99.66	0.5805
Isoamyl "	$C_5H_{11}C_5H_9O_2$	86	460.5°	0.698435	56.2[5]	90.64	0.6200

The curves representing the valerates are shown in Fig. 6. The density curve is quite uniform. Schiff finds the heat of vaporization (H. V.) of isoamyl valerate to be 56.2 cal. and from the curve it will be seen that the heat per unit of volume (L.) should be 0.6200, but this constant could not be calculated since no determination of the specific gravity of this compound at its boiling-point has been made. However, assuming the curve to be correct, the specific gravity at the boiling-point becomes 0.698435. The only determination of the heat of vaporization (H. V.) of valeric acid on record is that of Favre and Silberman, which places it at 103.52 cal. This would give 0.6042 as the heat per unit of volume (L.), while according to the curve it should be 0.4310, which gives 73.83 cal. as the heat of vaporization (H. V.).

[1] Calculated by the data furnished by the curves shown in this paper.
[2] Schiff: *Ann. Chem.* (Liebig), **234**, 238.
[3] Favre and Silberman: *Ann. chim. phys.* [3], **37**, 464-470.
[4] Calculated by the data furnished by the curves shown in this paper.
[5] Schiff: *Ann. Chem.* (Liebig), **234**, 338.

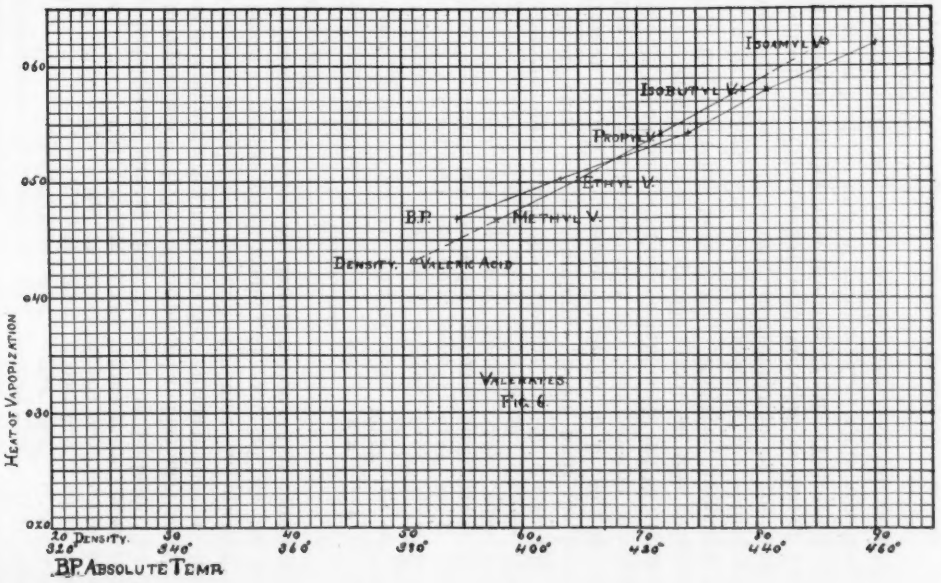

Heat of Vapopization
060
050
040
030
020
Isoamyl V.
Isobutyl V.
Propyl V.
Ethyl V.
B.P.
Methyl V.
Density. of Valeric Acid
Valerates.
Fig. 6
10 Density.
20
30
40
50
60
70
80
90
320°
340°
360°
380°
400°
420°
440°
460°
BP. Absolute Temp.

FIG. 6.

According to the boiling-point curve the boiling-point of propyl valerate 428.5° (absolute temperature) or 155.5° C. is a trifle too high.

Fig. 7 gives all of the density curves of the compounds above mentioned, in one diagram, showing that the relationship between them is very close and that the uniformity of the curves is very striking.

Fig. 8 is a similar combination of the boiling-point curves, showing the general tread of them to be almost that of a straight line.

ACIDS.

Name.	Formula.	D.	B. P.	S. G.	H. V.	V.	L.
Formic	$H.CHO_2$	23	373.8°	1.1175	92.71[1] 120.72[2]	542.26	0.2659 0.2226
Acetic	$H.C_2H_3O_2$	30	391.1°	0.9372	101.91[2]	348.66	0.2923
Propionic	$H.C_3H_5O_2$	37	413.7°	0.8589	90.42[3]	259.08	0.3490
Isobutyric	$H.C_4H_7O_2$	44	428.5°	0.8054	79.67[3]	204.29	0.3900
Butyric	$H.C_4H_7O_2$	44	435.5°	0.8120	82.79[3]	205.96	0.4020
Valeric	$H.C_5H_9O_2$	51	458.4°	0.7828	73.83[3]	171.30	0.4310

The curves of the acids (Fig. 9) are constructed as far as possible from their constants, as determined and recorded by the various observers, but otherwise the data used have been derived from the curves formed by their corresponding compounds.

The heat of vaporization (H. V.) of acetic acid as determined by Ramsey and Young seems to be too low as it does not conform to either the density or boiling-point curve.

ALCOHOLS.

Name.	Formula.	D.	B. P.	S. G.	H. V.	V.	L.
Water	H.OH	9	373.0°	0.9589	536.0[4]	1189.11	0.4507
Methyl alcohol	CH_3OH	16	339.2°	0.7483	263.86[2]	521.97	0.5055
Ethyl "	C_2H_5OH	23	351.3°	0.74035	201.42[5]	359.25	0.5607
Isopropyl "	C_3H_7OH	30	355.8°	0.7413	159.72[5]	275.78	0.5791
Propyl " (nor.)	C_3H_7OH	30	370.1°	0.7366	164.07[5]	274.03	0.5987
Isobutyl "	C_4H_9OH	37	381.4°	0.7265	136.16[5]	219.14	0.6213
Butyl " (nor.)	C_4H_9OH	37	389.96°	0.7269	138.18[5]	219.26	0.6298
Amyl "	$C_5H_{11}OH$	44	404.4°	0.7154	118.15[5]	181.46	0.6511

[1] Ramsey and Young: *J. Chem. Soc.*, Lond., 49, 790.
[2] Favre and Silberman: *Ann. chim. phys.* [3], 37, 464-470.
[3] Calculated by the data furnished by the curves shown in this paper.
[4] Regnault: Mem. Acad. Sci., 21, 638.
[5] Louguinine: *Compt. rend.*, 119, 601.

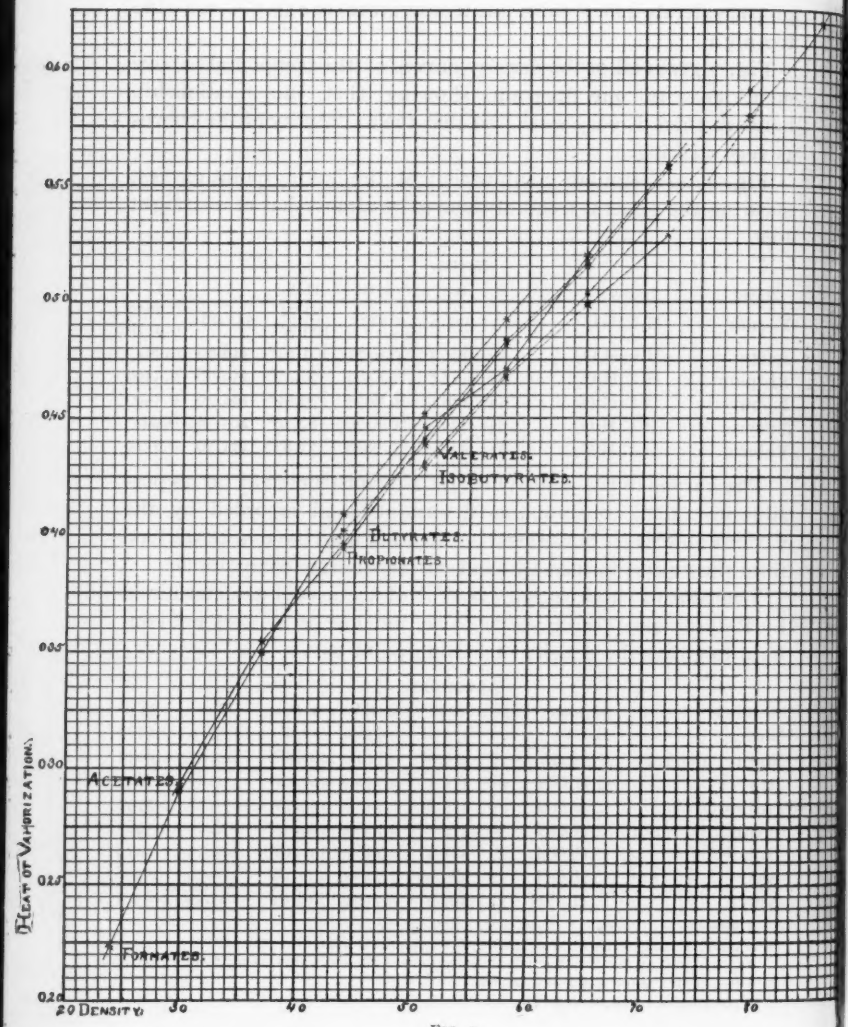

0·60
0·55
0·50
0·45
0·40
0·35
0·30
0·25
0·20
Heat of Vaporization.
20 Density 30 40 50 60 70 80
Valerated.
Isobutyrated.
Butyrated.
Propionated.
Acetated.
Formated.

FIG. 7.

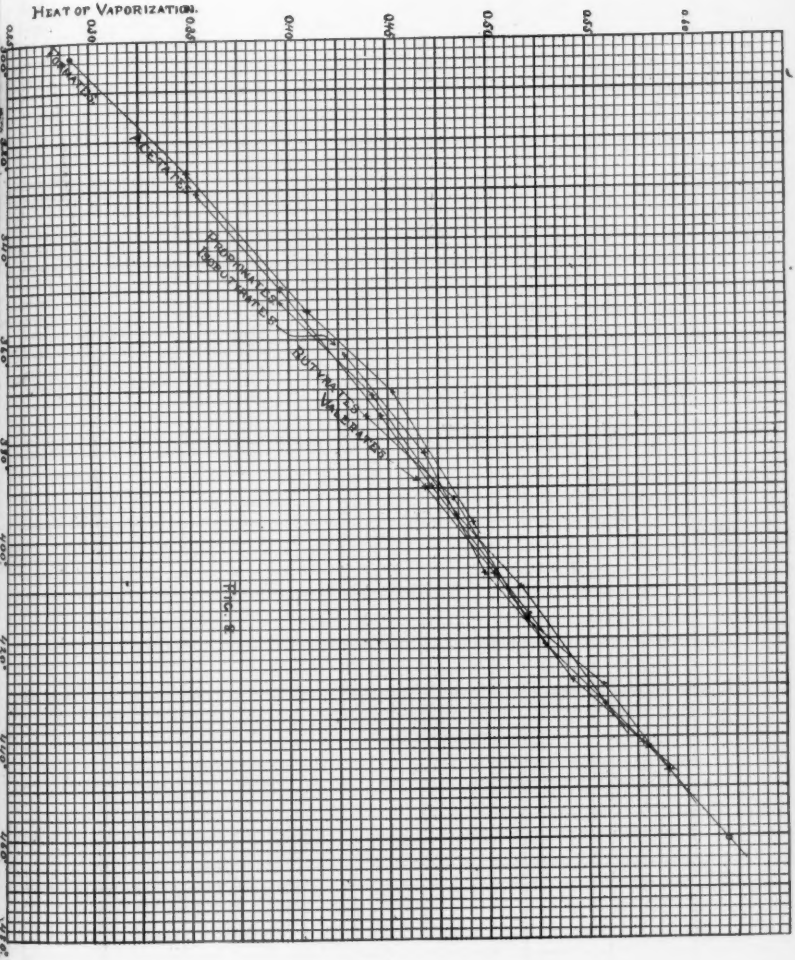

Heat of Vaporization.
0.040
0.050
0.060
0.070
0.080
0.090
0.100
Formic.
Acetic.
Propionic.
Isobutyric.
Butyric.
Isovaleric.
Valeric.
Fig. 8

Fig. 8.

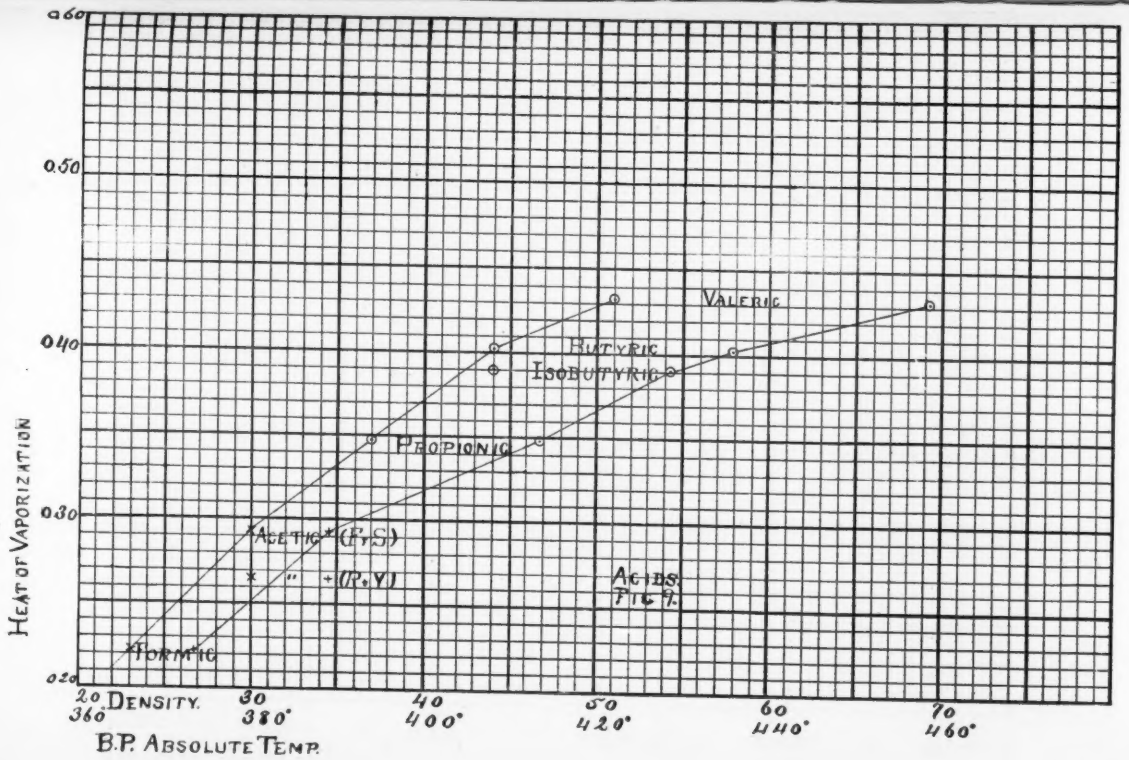

0.60
0.50
0.40
0.30
0.20
HEAT OF VAPORIZATION
VALERIC
BUTYRIC
ISOBUTYRIC
PROPIONIC
ACETIC (F, S)
(P, Y)
ACIDS. FIG 9.
FORMIC
20 DENSITY. 30 40 50 60 70
360 380° 400° 420° 440° 460°
B.P. ABSOLUTE TEMP.

FIG. 9.

The normal alcohols form quite symmetrical curves, as is shown in Fig. 10. In the density curve, water, as the type, falls in with the alcohols as the acids do with their corresponding compounds. It will be noticed that isopropyl and isoamyl alcohols do not fall into line with the normal alcohols, but, as might be expected, they form a portion of a curve for which the data relating to the remaining members of the series are not to be had at present.

In constructing the alcohol curves, the heat of vaporization (H. V.) of methyl alcohol, as determined by Favre and Silberman, was taken in preference to that of Diakonoff, which is believed to be an impossible value. These determinations are as follows:

Favre and Silberman	263.86 cal.
Diakonoff	123.79 "

In the case of ethyl alcohol the determination of Longuinine was used, although three determinations are recorded as follows:

Favre and Silberman	208.92 cal.
Andrews	202.40 "
Longuinine	201.42 "

Of the two determinations of propyl alcohol (normal)

Diakonoff	165.92 cal.
Longuinine	164.07 "

I have made use of the latter.

Two determinations of amyl alcohol (by fermentation) are recorded, *viz.*:

Favre and Silberman	121.37 cal.
Longuinine	118.15 "

and I have used the latter.

The determinations of the other alcohols given in the above table have been made only by Longuinine.

HYDROCARBONS.

Sufficient data has been found to make it possible to construct curves for a portion of the C_nH_{2n-6} series of the hydrocarbons, as follows:

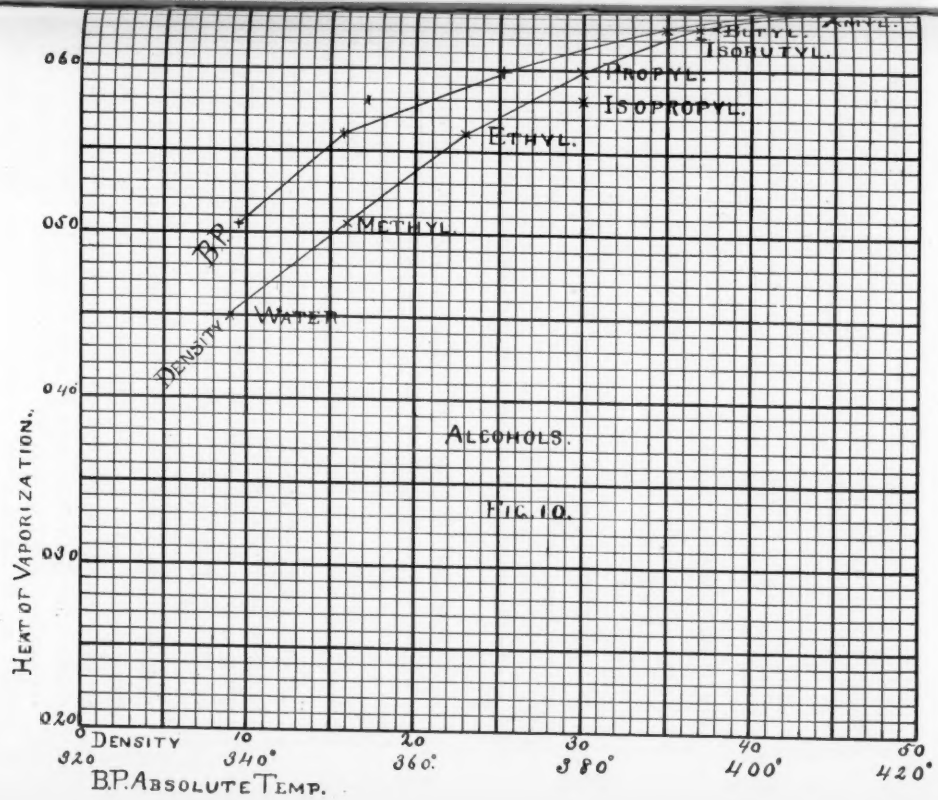

HEAT OF VAPORIZATION.
060
050
040
030
020
0
DENSITY
10
20
30
40
50
320
340°
360°
380°
400°
420°
B.P. ABSOLUTE TEMP.
B.P.
DENSITY
WATER
METHYL.
ETHYL.
PROPYL.
ISOPROPYL.
BUTYL.
ISOBUTYL.
AMYL.
ALCOHOLS.

FIG. 10.

FIG. 10.

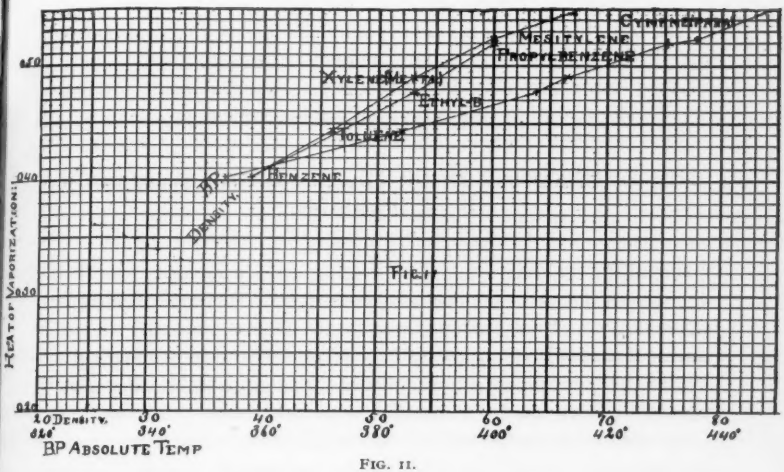


FIG. 11.

Name.	Formula.	D.	B. P.	S. G.	H. V.	V.	L.
Benzene	C_6H_6	39	353.35°	0.8111	93.45[4]	232.11	0.4026
Toluene	C_7H_8	46	383.8°	0.77694	83.55[4]	188.49	0.4432
Ethyl benzene	C_8H_{10}	53	407.7°	0.7612	76.4[4]	160.29	0.4766
Xylene (meta)	C_8H_{10}	53	412.9°	0.75715	78.25[4]	159.44	0.4908
Propyl benzene	C_9H_{12}	60	430.2°	0.7399	71.75[4]	137.63	0.5213
Mesitylene	C_9H_{12}	60	435.7°	0.7372	71.75[4]	137.12	0.5232
Cymene	$C_{10}H_{14}$	67	448.0°	0.7248	66.3[4]	120.73	0.5491

As will be seen in Fig. 11 these hydrocarbons form two density curves; one is formed by benzene, ethyl benzene, and propyl benzene, and the other by benzene, toluene, xylene, mesitylene, and cymene. The boiling-point curve is fairly regular and contains all of the series.

CONCLUSION.

From the foregoing we may enunciate the following law, *viz.*:

"In any homologous series, the heat of vaporization in a unit of volume of the vapor, under the same conditions as to temperature and pressure, is proportional to the density and also to the absolute boiling-point."

It will be noticed that the acid radical in any series fixes the

[4] Schiff: *Ann. chem.* (Liebig), **234**, 338.

characteristic of the curve, *i. e.*, the acid radical is the basis of the structure of the molecule, and the bases in combination with it, do not alter the general molecular architecture.

When more complete data have been obtained some interesting developments in this direction may be expected.

VANDERBILT UNIVERSITY.

THE DETERMINATION OF METHANE AND HYDROGEN BY EXPLOSION.[1]

BY AUGUSTUS H. GILL AND SAMUEL P. HUNT.[2]

Received September 26, 1895.

IN making an analysis of illuminating gas by Hempel's method it was noticed that the determination of the constituents by explosion was by no means as accurate as that made by absorption. This had been observed by Hinman[3] and is probably due (1) to the fact that an aliquot part of the residue (after all absorptions had been made) containing the methane and hydrogen is used, necessitating the multiplication of errors by a factor as large as four or five, and (2) to the possible absorption of the carbon dioxide formed by the water in the burette. To obviate these difficulties, it was determined to use all the gas left after the absorptions had been made, mercury as the confining liquid and to explode with pure oxygen rather than with air. Instead of using the gas left after the actual absorptions, which would be of unknown composition and troublesome to obtain, an artificial mixture, made from methane, hydrogen and nitrogen, approximating closely to the composition of the residue, was employed.

Preparation of the Gaseous Mixtures.—The hydrogen was prepared by the electrolysis of water; it was then shaken up with potassium pyrogallate to remove the slight quantity of oxygen with which it was mixed, and upon analysis was found to contain four and two tenths per cent. of nitrogen. In making an analysis of hydrogen, we would lay especial emphasis upon the necessity of having the ratio of explosive mixture to inert gases as great as 1:6 as Hempel[4] recommends, in order not to burn the nitrogen.

[1] Prepared for the Springfield Meeting, August 28, 1895.

[2] The work described in this paper formed the basis of a thesis presented by Mr. Hunt to the Faculty of the Massachusetts Institute of Technology for the Degree of Bachelor of Science.

[3] Massachusetts Senate Document No. 16, 1892. Inspection of Gas and Gas Meters, p. 12.

[4] Hempel, "Gasanalytische Methoden" p. 132.

This is considerably larger than that which Bunsen[1] recommended, which may vary between the limits twenty-six and sixty-four of combustible gas to 100 of incombustible. Unless the larger ratio be adopted the determination of hydrogen may come two and a half per cent. high, as is shown by the following table:

TABLE I. DETERMINATION OF THE PURITY OF THE HYDROGEN.

Hydrogen taken cc.	Air used cc.	Ratio.	Per cent. hydrogen.
20.5	185.0	1 : 5.7	95.8
20.5	185.0	1 : 5.7	95.8
50.0	115.0	1 : 1.2	98.3
50.0	115.0	1 : 1.2	98.0

The nitrogen probably burns to N_2O_4, as the characteristic dark red fumes of this gas were frequently seen in the pipette. By the Griess test with α-naphthylamine we were able to prove the presence of quite a quantity of nitrites in several cases.

In making the analyses of hydrogen by the first method it was necessary to connect and disconnect the burette three times in each case; the error which might be introduced was determined with the following results:

TABLE II. SHOWING THE ERRORS IN MANIPULATION IN CONNECTING THE BURETTE AND PIPETTE.

Burettefuls.	Air put in cc.	Air taken out cc.	Errors cc.	Remarks.
3	210.3	207.4	−2.9	No connections wired.
3	216.0	216.6	+0.6	
3	210.2	208.7	−1.5	
3	213.3	213.8	+0.5	All connections wired but one.
1	97.6	97.2	−0.4	All connections wired.
1	97.2	96.8	−0.4	
3	237.5	237.3	−0.2	

The oxygen was obtained in a similar manner to the hydrogen and contained one and six-tenths per cent. hydrogen and one and four-tenths per cent. nitrogen. The nitrogen in both these gases probably came from the distilled water electrolyzed, which was not freshly boiled before use.

The nitrogen employed was prepared by removing the oxygen from the air by means of phosphorus, allowing the gas to stand in the light twenty-four hours to decompose any ozone, and subsequent treatment with a small quantity of alkaline pyrogallate.

[1] Bunsen, "Gasometrische Methoden" (1877) p. 73.

An attempt was made to prepare the methane by the usual method of heating sodium acetate with sodium hydroxide and quicklime; the gas was found to be so largely contaminated with hydrogen,—as high as ten per cent. being found—as to be unfit for our purpose. This result is directly at variance with the statement of Freyer and Meyer[1] who say that this process "furnishes a very approximately pure gas."

Nor did the method of Gladstone and Tribe,[2] the reaction of a zinc-copper couple upon methyl iodide, at first yield any better results, owing possibly to the water in the alcohol used. To obviate this and also prevent the possible formation of ethane, anhydrous methyl alcohol was substituted for the ordinary alcohol usually employed. The air in the apparatus was displaced by carbon dioxide and the methane collected, treated with potassium hydroxide to absorb this impurity. An analysis of the gas thus made, by explosion with oxygen and also with air—care being taken to avoid burning any nitrogen—showed the methane to be chemically pure.

The gases thus prepared and also the mixtures made from them, were stored in bottles provided with doubly-perforated rubber stoppers carrying a tube for the introduction of water and a tube for the egress of the gas. To render these absolutely tight, the stoppers were fastened in by fitting a brass plate to cover the top of the stopper, and by means of brass bolts and nuts passing through wire loops around the neck of the bottle, pressing the stopper firmly into the neck of the bottle. Joints of this kind are sufficiently tight to withstand a pressure of hydrogen.[3] To reduce the possibility of the transfusion of the gases to a minimum, a slight outward pressure was maintained in each bottle and it was inverted in a pan of water. The separate gases were kept in this way for about two months, freshly distilled water being used to displace the quantities requisite for the various mixtures. These mixtures made from them stood in no case over two days, before being completely used up, so that the amounts of methane and hydrogen dissolved by the distilled water, used to displace the various volumes taken, were negligi-

[1] *Ztschr. phys. Chem.*, 11, 28.
[2] *J. Chem Soc.*, 45, 154.
[3] Gill: *J. Anal. Appl. Chem.*, 6, 601.

ble ; the coefficients of absorption of the various gases not being widely different the ratio of the gases would remain the same within the errors of the analysis.

The gases were mixed by displacing the water from a liter bottle with the proper amounts of methane, hydrogen and nitrogen—measured by a burette—care being taken to leave some of the water to act as a stirrer, and then thoroughly shaking the bottle. By connecting this with a bottle of distilled water by means of a siphon, the requisite quantity of gas for an experiment could be displaced into the burette.

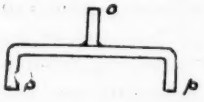
Method of Procedure.—Fifty cubic centimeters—this being about the usual residue from Boston gas after all the absorbable constituents had been removed—were measured out, mixed with about sixty cc. of oxygen and burned in an explosion pipette devised by one of us.[1] This combustion took place in different ways, at first as one explosion, and later by two explosions, with the idea of diminishing the error due to the possible combustion of nitrogen. In using the latter method it was found necessary to make the ratio of the explosive mixture to inert gases, nearly 1 : 2 in order that any explosion might take place ; with some mixtures not strong enough to explode, if care be not taken to pass the spark but a short time, the fine platinum wire becomes heated and finally glows, similar to the platinum sponge in the Döbereiner lamp, producing a very slow combustion, causing annoyance and delay in the analysis. A rough experiment may very well be made at first, to determine the composition of the gas under investigation and then suitable quantities of oxygen added for the first and second explosion.

The residue in the explosion pipette was, in every case, transferred to an ordinary Hempel burette for measurement, mercury, instead of water, being the confining liquid ; the gas was passed into potassium hydroxide and then into pyrogallate for the determination of carbon dioxide and oxygen. It is almost impossible to avoid sucking back some of the absorbents into the burette, which being strongly alkaline, would vitiate the next analysis by absorbing carbon dioxide ; to obviate this difficulty the instrument was washed out with dilute acetic acid[2] and then with

[1] Gill : *J. Am. Chem. Soc.*, 17, 771.

[2] If hydrochloric acid be used it forms a precipitate of mercurous chloride upon the walls of the pipette, coming from the mercurous salts produced by the action of the oxides of nitrogen upon the mercury.

water, almost filled with mercury allowed to stand about half an hour, the water which collected at the top displaced and then used for the next determination.



Instead of using the ordinary doubly bent connecting tube, this was varied by the introduction of a T joint, which is found especially convenient in adding successive portions of oxygen. The burette being connected at b, the pipette at p, and the oxygen at o, one can add the oxygen without disconnecting the burette each time. By connecting in a short tube at o, and filling it with mercury, the capillaries can be filled with mercury, an important point in preventing the rubber connectors from being burst by the force of the explosion. All connections should be carefully wired. By the use of two sets of apparatus two analyses may be executed at one time, in one an absorption be taking place, in another an explosion, etc. Six analyses in three hours were frequently made.

Calculation of Results.—The calculation of the results of the explosion was made according to the directions of Hempel,[1] that is in accordance with the reactions:

$$CH_4 + 2O_2 = CO_2 + 2H_2O.$$
$$2H_2 + O_2 = 2H_2O.$$

The volume of carbon dioxide obtained represents the methane present, and twice this volume subtracted from the total contraction, gives the contraction due to hydrogen; this latter being multiplied by two-thirds, gives the amount of hydrogen present. Table III shows the results obtained.

TABLE III.—ANALYSIS OF A MIXTURE OF METHANE, HYDROGEN AND NITROGEN BY ONE EXPLOSION WITH OXYGEN.

Mixture cc.	Oxygen per cent.	Methane per cent.	Hydrogen per cent.	Nitrogen per cent.
49.8	65.2	34.7	54.8	10.5
51.9	65.0	35.3	54.1	10.6
49.7	65.6	35.1	53.9	11.0
50.1	61.3	34.5	55.0	10.5
51.5	61.8	35.0	53.6	11.4
59.4	72.8	34.4	55.0	10.6
49.4	56.2	34.3	55.0	10.7
49.2	56.0	34.0	54.9	11.1
49.2	58.3	33.4	55.0	11.6
49.9	55.6	34.8	54.9	10.3
	Average	34.5	54.7	10.8
	Theory	34.7	53.5	11.8

[1] *Loc. cit*, 217.

The results obtained in the estimation of the methane are quite satisfactory and are probably within the limits of error of the apparatus. The hydrogen is high, due to the fact that the methane is low, and possibly also to the burning of the nitrogen.

In order to diminish the error from the latter source, a new mixture was made, and analyzed by exploding twice successively with oxygen, care being taken to add as little oxygen for the first explosion as would make the mixture combustible. Table IV shows the results obtained.

TABLE IV.—ANALYSIS OF A MIXTURE OF METHANE, HYDROGEN AND NITROGEN BY TWO EXPLOSIONS WITH OXYGEN.

Mixture cc.	Oxygen used first time.	Oxygen used second time.	Methane per cent.	Hydrogen per cent.	Nitrogen per cent.
51.2	40.0	40.9	32.6	46.6	20.8
51.1	41.0	39.9	32.0	46.5	21.5
56.7	40.0	50.3	32.1	46.7	21.2
48.5	31.0	45.7	32.2	47.5	20.3
50.3	31.0	49.8	32.4	48.0	19.6
50.9	32.0	51.1	32.3	47.6	20.1
53.4	35.0	45.6	31.7	48.1	20.2
50.9	30.0	52.9	32.1	48.1	19.8
49.3	29.0	47.7	32.2	47.9	19.9
50.7	31.0	49.6	32.3	48.5	19.2
		Average	32.2	47.55	20.25
		Theory	32.2	47.7	20.1

The results are very satisfactory and if we compare them with those of the preceding table (III), we see that the average is more nearly correct than that of the former, and the deviations from the mean much less. The first three present the greatest variation in regard to hydrogen, it being one per cent. too low, these two had the greatest proportional amount of oxygen in the first explosion which is anomalous.

In order to obtain an idea of what takes place during the first explosion, several were performed and the per cents. of methane and hydrogen which burned determined.

TABLE V.—SHOWING THE AMOUNT OF METHANE AND HYDROGEN BURNED WHEN AN INSUFFICIENT QUANTITY OF OXYGEN IS PRESENT.

		Methane			Hydrogen		
mixture cc.	oxygen cc.	present cc.	burned cc.	burned per cent.	present cc.	burned cc.	burned per cent.
53.0	29.2	17.1	4.0	23.4	25.0	12.5	50.0
53.4	29.1	17.2	4.3	25.0	25.2	11.7	46.3
55.0	33.6	17.7	4.9	27.7	26.0	16.7	64.3
57.4	35.2	18.5	5.2	28.1	27.1	17.0	63.8

About sixty per cent. of the hydrogen burned and, contrary to the usual opinion, twenty-five per cent. of the methane and only about fifty per cent. of the oxygen.

By way of comparison with the usual method, a series of analyses of the same mixture was carried through, employing a smaller quantity and exploding with air; the mercury explosion pipette was used as before and the residue after explosion measured in a burette using water, as is customary, instead of mercury as the confining liquid.

TABLE VI.—ANALYSIS OF A MIXTURE OF METHANE, HYDROGEN AND NITROGEN BY EXPLODING WITH AIR.

Mixture cc.	Air cc.	Methane per cent.	Hydrogen per cent.	Nitrogen per cent.
17.8	79.8	29.8	45.3	24.9
15.3	82.2	31.4	49.3	19.3
16.3	81.4	33.7	42.5	23.9
15.9	82.4	31.4	38.6	30.0
16.1	78.2	39.1	30.4	30.5
16.8	80.5	33.3	42.3	24.4
16.1	82.0	30.4	44.1	25.5
16.2	81.2	36.4	33.4	30.2
15.8[1]	79.5	31.6	40.0	28.4
15.1	82.5	33.8	38.0	28.2
16.2	82.6	31.2	42.9	25.9
14.8	83.8	34.4	38.4	27.2
15.9	84.3	33.9	37.7	28.6
	Average	33.1	42.2	26.7
	Theory	32.2	47.7	20.1
	Deviation	+0.9	−7.5	+6.6

These figures substantiate those of Hinman,[2] the results for methane and nitrogen being high and those for hydrogen low, the variations between the different analyses are even more marked. It is to be noticed that, contrary to expectation, the results upon the methane are high, indicating perhaps that the water in the burette is without appreciable solvent action upon the carbon dioxide formed. The discrepancy in the estimation of hydrogen is explained by the increase in the percentage of methane, any increment here being first doubled and subtracted from the "total contraction," and then approximately doubled in making the calculation, lowering as a consequence the hydro-

[1] These last five were measured after explosion with the mercury burette.

[2] *Loc. cit.*

gen by about four per cent., leaving three and five-tenths per cent. to be accounted for.

Almost the only supposition to account for this phenomenon is the somewhat anomalous one, that under these conditions the hydrogen is not completely burned.

In order to determine the effect of certain errors, such as the reading of the burette—graduated in fifths of a cubic centimeter—and any mistakes made in transferring the gases, the foling assumptions were made (Table VII), and the deviations these might produce were calculated by the method of least squares, with the results showed in Table VIII.

TABLE VII.—SHOWING THE VOLUME OF GASES TAKEN AND THE ERRORS ASSUMED IN THEIR MEASUREMENT AND MANIPULATION.

	Oxygen method. cc.	error.	Air method. cc.	error.
Gaseous mixture taken	50.	0.15	15.	0.15
Oxygen (or air) used	60.	0.15	85.	0.15
Residue after explosion	33.	0.25	21.	0.25
Carbon dioxide formed	16.	0.25	5.	0.25

TABLE VIII.—SHOWING THE DEVIATIONS TO BE EXPECTED IN THE DETERMINATIONS OF THE VARIOUS GASES UPON THE ASSUMPTIONS IN TABLE VII.

	Oxygen method. per cent.	Air method. per cent.
Methane	0.51	1.64
Hydrogen	0.82	2.40
Nitrogen (by difference)	1.70	4.30

The results of this investigation may be summarized as follows:

(1) The method of preparation of methane by heating sodium acetate, hydroxide and lime together does not yield a pure gas.

(2) The method of determination of methane and hydrogen by one explosion yields results accurate to less than five-tenths per cent. of the methane and three-tenths per cent. of the hydrogen.

(3) The method by two explosions yields results with in two-tenths per cent. of methane and three-tenths per cent. of the hydrogen.

(4) When a mixture of hydrogen and methane is exploded with a quantity of oxygen insufficient for both, but more than sufficient for either, about sixty per cent. of the hydrogen and

twenty-five per cent. of the methane and fifty per cent. of the oxygen are consumed.

(5) The method of determination of the gases by one explosion with air gives results not within nine-tenths per cent. of the methane and seven and five-tenths per cent. of the hydrogen.

In concluding this article we would express our indebtedness to Mr. R. B. Price for preliminary work which served as the foundation of this thesis.

NEW BOOKS.

A Manual of Qualitative Chemical Analysis. By E. P. Harris, Ph.D., LL.D., Professor of Chemistry in Amherst College. New edition. Thoroughly revised and corrected. Amherst, Mass.: Carpenter & Morehouse. 1895. pp. 308. Price $1.50.

The author of this book is a veteran teacher, and this new edition is the result of the experience of his laboratory teaching for over a third of a century. The book is divided as follows:

Part I. Examination of solutions: Sec. I, Bases; Sec. II, Acids.

Part II. Examinations of solids.

Part III. Qualitative separations: Sec. I, Bases; Sec. II, Acids.

Supplement: Reaction of rare elements; Use of the spectroscope in analysis.

Appendix: Preparation of reagents; Table of solubility; Index.

Part first gives the reactions of each of the metals and acids, and is interleaved that the student may write out the reaction-equations on the blank pages. This is intended to be used in connection with unknown solutions containing a single base and acid.

Part second is a guide to the systematic examination of solids according to the plan which was first introduced by the author and has since been very generally adopted. This is perhaps the most valuable part of the book.

Part third takes up the separations of metals systematically, using the methods which have proved most satisfactory in the Amherst laboratory. Alternate methods are in a number of instances given, but generally only a single method; the idea is to avoid confusing the student with a number of different ways of working, the relative merits of which he is incapable of estimating. This part is very complete, covering practically all cases

with the common metals and acids, while it is well supplemented by a very comprehensive chapter on the reactions of the rare metals.

The appendix on the preparation of reagents will be found useful to teachers.

This manual is not intended to merely make the student a good analyst; it is rather a manual of instruction in chemistry through the medium of qualitative analysis. It is not a book for self-instruction, but it is intended that the student shall have the constant supervision of an instructor. As a manual for college students it does not appear to be too much to say that of all the many books of its class it is the best.

JAS. LEWIS HOWE.

PRINCIPLES AND PRACTICE OF AGRICULTURAL ANALYSIS. By HARVEY W. WILEY. VOL. II. FERTILIZERS. Cloth, 8 vo. pp. 332. Easton: Chemical Publishing Co. 1895. Price, $2.00.

The official inspection of fertilizers involves such great pecuniary interests that the chemical methods used for the purpose are matters of the highest importance to analyst and manufacturer. All countries in which fertilizers are used to any extent have some plan of inspection and certain methods of conducting the chemical work required. These methods are the result of very numerous and often difficult investigations of the men best qualified to deal with the subject.

In the volume under consideration the subject of fertilizers is treated under four heads: (1) Phosphates and phosphatic fertilizers; (2) Nitrogen in fertilizers and fertilizing materials; (3) Potash in fertilizing material and fertilizers; (4) Miscellaneous fertilizers, lime, gypsum, ashes, coarse manures, etc.

The matter of drawing samples of various materials receives a deservedly large share of attention. Then the analytical work proper is taken up and treated very fully and clearly. The different analytical methods of various countries are given in full and a brief but very valuable discussion of the merits of the methods follows. In many cases the value of the discussion is increased by full statements of analyses.

The matter thus brought together consists of both original matter and material published at home and abroad; and often published in such a way as to be now inaccessible to many workers on the subject.

The treatment of the subject is full, clear, systematic, and well up to date. Enough technology is included to show the reader the reason for the methods used in the work ; and the author has not lost sight of the fact that he is writing on the principles as well as the practice of agricultural analysis.

The chemist who has been unfortunate enough to buy a number of alleged treatises on agricultural chemical analysis (chiefly of English origin) that have recently appeared will fully appreciate the merits of this work and heartily thank Dr. Wiley for producing a work that is full and reliable. For if the investigator of questions bearing on the analysis of fertilizing material does not find here methods suitable for the purpose he has in view, he may as well resign himself to working the matter out for himself.

To the teacher the book is of very great value, and if used by students they will have the satisfaction of knowing that they are well prepared for technical work in factory or inspection laboratories.

The full citation of authorities and an unusually complete table of contents and index are commendable features of the work.

In the preface, the author regrets "that the contents of the volume have again exceeded all expectations." His readers will not share this regret, for there is nothing here that could have been omitted to advantage.

It is to be hoped that there may be no delay in the appearance of the remaining volumes of a work that is of such high value to those who wish to keep informed on so wide a range of chemical work as is included under the term agricultural analysis.

H. A. HUSTON.

LABORATORY WORK IN CHEMISTRY. A SERIES OF EXPERIMENTS IN GENERAL INORGANIC CHEMISTRY. BY EDWARD H. KEISER. 8 vo. viii, 119 pp. New York : American Book Co.

This little book, in spite of its name, is not exclusively a laboratory guide nor is it exclusively devoted to experiments in inorganic chemistry. Thus, we find (p. 62) a definition of *equivalent*, and a description of the properties of carbon (p. 94). The experiments relating to the organic compounds, marsh gas,

ethylene, and calcium carbide do not strike one as being very instructive or *apropos* of anything in particular.

An excellent feature is the introduction of numerous questions, although these might, perhaps with advantage, have been more closely confined to the subjects of the experiments. It is not easy to see, for example, why such a question as the following should be brought into a laboratory manual: "Which elements make up three-fourths of the solid crust of the earth?"

A number of the more difficult experiments, such as the gravimetric determination of the composition of water are to be performed by a few more advanced students for the benefit of all, a commendable arrangement when the classes are not too large.

The experiments are, in the main, well selected and described in simple and clear English. The use of the term "arseniuretted hydrogen" is a curious anachronism in a book which for the rest adheres to a modern nomenclature.

L. W. ANDREWS.

BOOKS RECEIVED.

Kentucky Agricultural Experiment Station, Bulletin No. 56. Analysis of Commercial Fertilizers. Lexington, Ky.

Kentucky Agricultural Experiment Station, Bulletin No. 57. (1) Wheat Experiments. (2) Oat Experiments. Lexington, Ky.

Texas Agricultural Experiment Station, Bulletin No. 36. Vegetable Insecticides. College Station, Brazos County, Texas.

NOTE.

The Banquet to Messrs. Mond and Tyrer.—Two prominent English chemical manufacturers, Messrs. Ludwig Mond, a member of the well-known firm of Brunner, Mond & Co., and Thomas Tyrer, a manufacturer of pharmaceutical chemicals and now President of the Society of Chemical Industry, have been paying a visit to the United States. There has naturally been considerable desire among American chemists to meet these gentlemen, and they have received many invitations and courtesies. An account of Mr. Tyrer's visit to the meeting of the

Lehigh Valley Section of the American Chemical Society will be found in the Proceedings issued with the November number of this Journal.

On the evening of November 1, ninety-one chemists took part in a farewell banquet at Delmonicos. The after-dinner speakers were Mr. Alfred Mason, of New York, who presided, Thomas Tyrer, Ludwig Mond, Peter Townsend Austen, Seth Low, W. H. Nichols, and H. W. Wiley. Impromptu remarks were also made by J. H. Appleton and Walter H. Bunn. A verbatim account of the remarks made is contained in the *New York Oil, Paint and Drug Reporter*, November 4, from which this account is condensed.

It is quite impossible in the space available to do justice to all that was said. The addresses made were all enjoyable, some of them brilliant, and the festivities were ably and wittily directed by Mr. Mason.

Mr. Tyrer, who spoke for the Society of Chemical Industry, after referring to the early history of the Society, expressed his appreciation of the courtesies received during his visit, his belief in the greatness of our industrial future, and his admiration of our institutions of learning.

Professor Austin spoke for the N. Y. Section of the American Chemical Society. Among other things, he said:

"In this country the practical chemist and the teacher have little time left for purely scientific research and in this we cannot compete at present with Europe. But I am sure the time will come when we can. I have unlimited confidence in American brains. Industrial chemical investigation is no less difficult, no less honorable than purely scientific research. If any investigator in pure science doubts this let him try his hand at cracking some technical nut. Let him, for instance, get up a profitable process for making sodium permanganate for our colleague, Mr. Tyrer. * * * What we need now in this country is the establishment of departments of chemical engineering in our larger colleges. * * To understand the chemistry of manufacturing is one thing, to be able to handle a chemical reaction mechanically is quite another matter."

Mr. Mond responded for the guests, he said:

"I feel proud that while so many miles from home I am yet no stranger among you. * * Professor Austen has remarked that investigation in technical chemistry is quite as difficult as investigation in pure science. There is, however, this great difference that investigation in

pure science bears fruit for centuries to come. Every discovery of new truth is an increase of knowledge and is a benefit to humanity. Technical matters come and go and make room for more perfect methods as time goes on. It is therefore true that a man who devotes himself to pure science deserves the gratitude of future generations as well as his own. We live more for our children and grandchildren than for ourselves, so we cannot do too much in encouraging men who are ready to devote their lives to the betterment of the future. It is extremely natural that in an immense country like this—but it is not right to call it a country or a continent; it is a hemisphere; it is half of this globe—that the few who develop this branch of science shall have little time to think of posterity. In looking at the magnificent institutions that have grown up in this country for the study of science I have very little doubt that the time is not far distant when very many of you will appreciate the importance of pure science more than you have ever done before, and the time will not be far distant when the number will be large enough to meet the wishes of men of science among you."

Mr. W. H. Nichols responded for the Chemical Manufacturers. He said:

"That knowledge is power is true, but how can it be power without the application of it, and how can we have the application without the engineer. * * There is one other thing in which we can imitate our friends on the other side of the water to advantage, and that is the way in which they come together and compare notes, and receive from one another benefits from the experience each has attained. In this country we have not grown enough to know not to be afraid of each other, and the manufacturing chemist of the United States is hiding his head in the sand like the ostrich * * * * * In the census of 1890 it was ascertained that there were 1626 manufacturing establishments in the United States. They employed a capital of over one hundred and sixty-eight million dollars, and hired property of the value of twelve million dollars, employing in the aggregate nearly 44,000 persons, and paying a total wage of more than twenty-five million dollars. I desire to call the attention of our guests to one or two facts connected with these employes. Of the total number a little less than 4,000 were females, but only 346 were children. That is one of the best statements I can make to show the condition of the manufacturing industry that it has been necessary to employ only 346 children."

The arrangements for the banquet were in the hands of a committee with J. H. Wainwright as chairman. They were well planned and the occasion was a most enjoyable and profitable one.

E. H.

Errata.—Page 759, October Number, in the table headed "MoO_3 in sample 10 Phosphomolybdate" the line Doolittle (Job) 90.47, 93.05, 95.80, should read Doolittle (Job) 89.88, 92.45, 95.18.

A TRIBUTE TO PASTEUR.[1]

A FEW weeks ago, one of the foremost scientists of the present century passed into the great beyond. Louis Pasteur, although a master mind in physics and geology, was preeminently a chemist, therefore it behooves our Society to express its regrets at the great loss sustained not only by France, but which the whole civilized world is obliged to bear. Men like Pasteur, whose life was spent in disseminating broad principles of truth, in alleviating pain, in mitigating epidemic diseases and in exterminating parasites whose activity threatened ruin to the agriculturists, cannot be narrowed down as belonging to one country; but on the contrary are veritable cosmopolites, deservedly honored and venerated by every nation.

It is not my intention to give a sketch of the life of Pasteur, but simply to call your attention, in a brief way, to some of his most important contributions to science and the effects produced. The one, that undoubtedly tended towards moulding his thoughts in the direction to which he devoted his best years was to combat the idea of Heterogenesis and it may truthfully be said that he succeeded in making it untenable by incontestable evidence in support of his theory, that: "The living organized ferments spring only from similar organisms likewise endowed with life; and that the germs of these ferments exist in a state of suspension in the air or on the exterior surface of objects." This not only disproved Fremy's Hemi-organism hypothesis but also Liebig's assertion that "The cause of fermentation is the internal molecular motion, which, in the course of decomposition, is communicated to other matter in which the elements are connected by very feeble affinity." Pasteur, by means of most thorough and extensive research, from 1857–61, simply forced the attention of everybody to the physiological side of the subject, and by absolutely unimpeachable evidence, proved that Schwann's views are correct. Of the investigation, both synthetical and analytical, it is impossible to speak otherwise than in terms of the highest admiration. Even the purely critical portion of Pasteur's work would be enough to immortalize his name. His theory, "That the chemical act of fermentation is

[1] Read before the Cincinnati Section, Oct. 15th.

a correlative phenomenon of a vital act, beginning and ending with it," notwithstanding the thousands of experiments since made by him and other investigators remains unshaken and is to-day the firm basis of all ideas respecting fermentation. Pasteur's researches, by their precision, the care taken to avoid all sources of error, and his rigorous exactness, removed every suspicion of the intervention of germs brought from without or preexisting in the liquid operated on, a difficulty on which all discussions between heterogenists and panspermists had heretofore turned. By means of the organic corpuscles of dust mixed with amorphous ones, obtained by filtering air through a gun-cotton plug and showing that their absence prevented sterilized fluids from fermenting, but their presence would cause it to set in, Pasteur elevated a hitherto merely observed phenomenon to a scientific basis. His experiments with the forty flasks of must, to show that the ferments which cause the fermentation in the vintage tube, must come from the exterior and not the interior of the fruit, as well as those made to discover quantitatively the germs in the air, are famous.

Pasteur's signal success in counteracting the effects of Pebrine which threatened to destroy the silk industry of France and Italy, not only saved thousands from absolute ruin but taught the people that infectious diseases could be combated by a most novel method. Consequently his efforts toward suppressing the ravages produced by chicken cholera and spleenic fever met with less popular prejudice. While experimenting on chicken cholera he produced cultures of varying degrees of virulence by permitting sufficiently long intervals to elapse between the impregnation of one culture with the microbe of the preceding. Furthermore, he proved that each culture of attenuated virulence reproduced the virulence of that which had served as the starting point; concluding from these experiments that the oxygen of the air was the possible cause of the attenuation. When fowls had been rendered sufficiently ill by the attenuated virus which the vital resistance arrested in its development, immunity from the original disease arose. Perhaps one of the most brilliant triumphs achieved by Pasteur consisted in taking advantage of the morphological changes taking place in the Anthracoid

microbe. He prevented it from producing corpuscle germs, kept it while in this condition in contact with oxygen, days, weeks, and months, and thus produced a series of attenuated virulences. With this vaccine he practically exterminated the spleenic or carbuncular disease throughout France.

To Pasteur we owe nearly all of our knowledge of the relations between the optical activity and crystalline form in tartaric acid. He showed that enantimorphism depended upon hemihedral forms of the rhombic system. His experiments in this direction led to the discovery of physiological asymmetry and paved the way for the study of elective fermentation. He proved that substances chemically and physically the same save in their opposite rotatory power can serve in one case as nutrients to certain organisms and in the other are worthless as such; and that only certain geometrical forms can serve the requirements of the cells. Thus we see Pasteur as one of the pioneers in the field of stereochemistry.

His successful method of counteracting rabies, his untiring labors in the interest of suffering humanity up to the time of his death forcibly recalls Tyndall's letter, written as far back as 1876. "For the first time in the history of science, we are justified in cherishing confidently the hope that, as far as epidemic diseases are concerned, medicine will soon be delivered from empiricism and placed on a real scientific basis; when that great day shall come, humanity will, in my opinion, recognize the fact that the greater part of its gratitude will be due to you."

Believe me ever faithfully yours,

JOHN TYNDALL.

France can well be proud of such sons as Lavoisier and Pasteur. Generations to come will recognize in their labors the possibility of unveiling, by means of conscientious scientific research, nature's most carefully treasured secrets.

Indeed Longfellow must have had such men in mind when he wrote,

"Lives of great men all remind us
We can make our lives sublime,
And, departing leave behind us
Footprints on the sands of time."

ALFRED SPRINGER.

Index to Vol. XVII, 1895.

ABSORBENT blocks 472
Acetanilide, identification of 933
Acetic acid and benzene, formation of layers in mixtures of 932
Acetic acid in vinegar 741, 834
Acetone, improvement in manufacture of 187
Air, analysis of Cleveland 105
Alkaloids, acedimetric estimation of vegetable 822
Allylmalonic, allylacetic and ethylidenepropionic acids, behavior when boiled with caustic soda 1
Aluminum and iron, separation of 931
Ammonium citrate solution, preparation of 47
ANDREWS, LAUNCELOT. On the Analysis of Alloys of Lead, Tin, Antimony and Arsenic 869
ANDREWS, W. H. See Campbell, E. D.
ANDREWS, W. H. A Cheap Form of Self-Regulating Gas Generator 304
Anthracene series, experiments in 354
Antimonial and arsenical poisoning, a case of 667
Antimony, arsenic, tin and lead alloys, analysis of 869
Antimony, precipitation from tartar emetic 87
Argon, 219, 421; compounds of, 422; use in thermometry 477
Arsenical and antimonial poisoning, a case of 667
Arsenic, antimony, tin, and lead alloys, analysis of 869
Arsenic in glycerol 883
Asphalt, analysis of 55
ATKINSON, ELIZABETH A., and Edgar F. Smith. The Separation of Iron from Beryllium 688
Atomic weights, report of commmittee on 201
AUCHY, GEORGE. The Volumetric Estimation of Manganese 943
Austin, Peter T., and W. A. Horton. A Convenient Form of Universal Hand-Clamp .. 611
AUSTIN, PETER T., and W. Homer Broadhurst. Absorbent Blocks 472

BACHMAN, IRVING A. Improved Methods of Water Analysis, 296: Chemical Brick for Glover Towers 360
Bacilli, Composition of 605
Banquet to Messrs. Mond and Tyrer 997
Barium Hydroxide Solution as an absorbent for carbon dioxide 247
Barley, Proteids of 539
BARTON, G. E. Methods for the Examination of Glycerol for use in the Nitroglycerol Manufacture, 277; Arsenic in glycerol 883
BASKERVILLE, CHAS. Reactions between Copper and Concentrated Sulphuric Acid See also Venable, F. P. 904
BASSETT, LEWIS L., see Fleck, Hermann.
Beadle, C. See Cross, C. F.
BEESON, J. L. A Simple and Convenient Apparatus for Estimating the Water-Holding Power of Soils 769
Benzene and acetic acid, formation of layers in mixtures of 932
Beryllium. See Glucinum.
BEVAN, E. J. See Cross, C. F.
BIGELOW, W. D. Coloring Matter in the California Red Wines 213

BLAIR, A. A., and J Edward Whitfield. Ammonium Phosphomolybdate and the Reducing Action of Zinc in the Reductor 747
BLASDALE, WALTER C. On the Physical and Chemical Properties of Some California Oils..... 935
BLOMÉN, J. E. Some Practical Points in the Manufacture of Nitroglycerol, 263; On the Manufacture of Soluble Nitrocellulose for Nitrogelatine and Plastic Dynamites..... 411
Bone Black. analysis of, 51; decarbonization of..... 503
Books Received.....916, 997
BOOK REVIEWS. A Text-Book of Volumetric Analysis (Schimpf) 69; A Text-Book of Inorganic Chemistry (Newth) 71; Die Maschinellen Hilfsmittel der chemischen Technik (Parnicke) 74; The Elementary Nature of Chlorine, Alembic Club Reprint No. 9 (Sir Humphrey Davy) 74; A Treatise on Industrial Photometry, with Special Application to Electric Lighting (Palaz) 151; Descriptive Inorganic General Chemistry (Freer) 152; A Text-Book of Inorganic Chemistry (Bennett) 243; Qualitative Analysis of Inorganic Substances, 245; Proceedings of the 11th Annual Convention of the Association of Official Agricultural Chemists (Wiley), 330; Bibliography of Acetoacetic Ester and its Derivatives (Seymour), 332; Report on the Extent and Character of Food and Drug Adulteration (Wedderburn), 333; Eighth Annual Report of the Dairy and Food Commissioner of Ohio, 333; First Annual Report of the Commissioner of Agriculture of New York (Schraub), 333; A Compilation of the Pharmacy and Drug Laws of the several States and Territories (Wedderburn), 333; Kräfte der chemischen Dynamik (Stettenheimer), 336; Elements of Qualitative and Quantitative Chemical Analysis (Caldwell), 419; Elementary Qualitative Chemical Analysis (Clowes), 419; Handbuch der Stereochemie (Bischoff), 497; A Text-Book of Organic Chemistry (Bernthsen), 500; Manual of Chemistry (Simon), 501; Cod Liver Oil and Chemistry, 584; The Increase in Weight of Tin and Lead on Calcination, 585; A Text-Book of Chemistry Intended for the use of Pharmaceutical and Medical Students (Sadtler and Trimble), 656; John Dalton and the Rise of Modern Chemistry (Roscoe), 658; An Elementary Course in Experimental and Analytical Chemistry (Long), 744; Elements of Mineralogy, Crystallography and Blowpipe Analysis (Moses and Parsons), 745; Elements of Modern Chemistry (Green and Keller), 832. Justus Von Liebig, His Life and Work (Shenstone), 833; Principles and Practice of Agricultural Analysis, Vol. I (Wiley), 912; A Hand-Book of Industrial Organic Chemistry (Sadtler), 914; A Manual of Qualitative Chemical Analysis (Harris), 994; Principles and Practice of Agricultural Analysis, vol. II (Wiley), 995; Laboratory Work in Chemistry (Keiser), 996.
BOWEN, N. C. The Penetration Machine—An Explanation 218
BOYER, CHARLES S. Accuracy of the Dyeing Test, 468; Interpretation of some results in the analysis of extracts of fustic 518
Butter, examination for foreign fats..... 719

CALCIUM carbide, properties of 306
Calcium sulphite, stalactites and stalagmites 242
CAMPBELL, E. D., and W. H. Andrews. The Determination of Nickel in Nickel-Steel 125
Cane sugar, determination in presence of glucose, 312; action of hydrochloric and acetic acids on..... 320
Carbides of iron with chromium (molybden and tungsten) 791
Chromium, determination in chrome ore..... 327
CLARK, EDMUND. Method of Determining Chromium in Chrome Ore..... 327
Clarke, F. W. Report on Atomic Weights Published during 1894 201
CLARKE, THOMAS, see Venable, F. P.
Coals, determination of heating effects of, ... 843
Condensation of nitric acid 576
Conflagrations, methods of extinguishing.....137, 251, 361
Copper and concentrated sulphuric acid, reactions between 904

Copper, the wet assay for 346
Cotton, intended for manufacture of gun-cotton, inspection of 783
CRAVER, H. W. See Noyes, W. A.
CROSS, C. F., E. J. Bevan and C. Beadle. The Furfurol-yielding Constituents of Plants 286
CUSHMAN, ALLERTON S., and J. Hayes-Campbell. On the Volumetric Determination of Lead 901

DEBENNEVILLE, JAMES S. Two Definite Carbides of Iron with Chromium (Molybdenum and Tungsten) 791
DECHALMOT, G. On Silicides of Iron 923
DENNIS, L. M. Gerhard Krüss (Obituary Notice) 423
DEROODE, RUDOLF. Some Facts Observed in the Determination of Phosphoric Acid by the Molybdic Acid Process, 43; The Addition of Calcium Chloride to the Solution of a Fertilizer in the Determination of Potash, 46; On the Preparation of Ammonium Citrate Solution, 47; The Determination of Potash in Kainite, 85; The Oxidation of Organic Matter and the Decomposition of Ammonium Salts by Aqua Regia in Lieu of Ignition in the Determination of Potash in Fertilizers 86
DE SCHWEINITZ, E. A., and Marion Dorsett. The Composition of the Tuberculosis and Glanders Bacilli 605
Diastase, chemical nature of 587
DOREMUS, C. A. The Chemical History of a Case of Combined Antimonial and Arsenical Poisoning 667
DORSETT, MARION. See DeSchweinitz, E. A.
DORRANCE, JOHN T. See Noyes, Arthur A.
DUBOIS, H. W. See Mixer, C. T.
DUDLEY, WM. L. The Relationship of the Heat of Vaporization of Gases to their Density and Also to their Boiling-Point 969
DULIN, R. S. The Wet Assay for Copper 346
DUNNINGTON, F. P. An Improved Gas Regulator 781
Dyeing test, accuracy of 468

EHRENFELD, CHARLES HATCH. A Study of the Chemical Behavior of Tungsten and Molybdenum 381
Electrolytic analysis: Separations, 612; determination of ruthenium 652
Electrolytic reduction of paranitro compounds 855
Electrolytic separations 612
Elements, early American arrangement of the 947
Explosion pipette, modification of Hinman's 771

FATTY acids, separation of solid and liquid 289, 740
Ferrates, the 760
Ferrocyanides, new indicator for, 473; use of organic bases in preparation of 927
Fire extinguishers 137, 251, 361
FLECK, HERMANN, and Lewis L. Bassett. Reduction with Magnesium Amalgam 789
Food of the future, the synthetic 155
Furfurol yielding constituents of plants 286
Fustic, interpretations of results in analysis of extracts of 518

GARRIGUES, W. E. The Determination of Potash in Manures 47
Gas analysis, modification of Hinman's explosion pipette, 771; Determination of methane and hydrogen by explosion 986
Gas generator, self regulating, 304; new 809
Gas regulator, improved 781
GILL, AUGUSTUS H. A Modification of Hinman's Explosion Pipette 771
GILL, AUGUSTUS H., and Samuel P. Hunt. The Determination of Methane and Hydrogen by Explosion 986
GLADDING, THOMAS S. The Determination of Sulphur in Pyrites 397
Glover towers, chemical brick for 360

Glucinum salts, purification of ..... 604.
Glucinum, separation from iron 688
Glucose syrup and grape sugar, acidity of, 402 ; ash in 403
Glucose, use of sulphites in manufacture of 281
Glycerol, examination of, 277 ; arsenic in, 883 ; occurrence of trimethylene glycol in, 890
Graphite in pig-iron, determination of 873
GRIFFITH, A. B. and Charles Platt. On the Composition of Pelagine 877
GROSVENOR, WILLIAM M., JR. Some new Solvents for Perchromic Acid 41
Group V of periodic system, action of hydrochloric acid gas upon salts of the elements of, 682 ; action of haloid acid upon 735
Gum-cotton, inspection of cotton intended for manufacture of 783

HAND-CLAMP, convenient form of 611
HANDY, JAMES O. The Superiority of Barium Hydroxide Solution as an Absorbent in Carbon Determinations in Steel 247
HARE, C. L. A New Table for the Qualitative Separation of the Metals of the Iron Group 537
HARRIS, EDWARD P. A New Generator 809
HARRIS, HARRY B. See Smith, Edgar F.
HART, EDWARD. On Condensation ; and Especially on the Condensation of Nitric Acid, 576 ; Some Points in the Distillation of Nitric Acid, 580 ; Note on the Purification of Glucinum Salts 604
HAYES-CAMPBELL, J. See Cushman Allerton S.
HEATH, G. L. The Estimation of Sulphur in Refined Copper 814
Heat of vaporization of gases, relation to density and boiling-point 969
Helium 421
HIBBARD, P. L. Quick Estimation of Starch 64
HIBBS, JOS. G. See Smith, Edgar F.
HILLEBRAND, W. F. Warning Against the Use of Fluoriferous Hydrogen Peroxide in Estimating Titanium 718
HINDS, J. I. D. A New Hydrogen Sulphide Generator (Note) 420
HITCHCOCK, FANNY R. M. The Tungstates and Molybdates of the Rare Earths. 483, 520
HOCHSTETTER, ROBERT W. See Hoffman, Lewis William.
HOFFMAN, LEWIS WILLIAM, and Robert W. Hochstetter. A New Form of Water-Oven and Still 122
HORNE, W. D. The Rapid and Accurate Analysis of Bone-Black, 51 ; The Decarbonization of Bone Black 503
HORTON, H. E. The Use of Sulphurous Acid ($HNaSO_3$) in the Manufacture of Glucose Syrup and Grape Sugar, 281 ; Alkali and Sulphurous Acid Processes Used in the Manufacture of Starch from Corn, 68 ; Acidity of Glucose Syrup and Grape Sugar, 402 ; Ash in Glucose Syrup and Grape Sugar 403
HORTON, W. A. See Austin, Peter T.
Hot air motor 494
HYDE, F. S. Scheme for the Identification of Acetanilide, Phenacetine, Quinine Sulphate, etc 933
Hydrogen and methane in the atmosphere, 801 ; determination by explosion 986
Hydrogen peroxide sometimes contains fluorine 718
Hydrogen sulphide generator, a new 420

Illuminating Apparatus 496
Indirect analysis of mixtures containing a common constituent 466
Iron and aluminum, separation of 931
Iron and titanic acid, volumetric determination in ores 878
Iron group, qualitative analysis of metals of 537
Iron in iron ores, Zimmerman-Reinhardt method for determination of 405
Iron, separation from glucinum 688
Iron, silicides of 923

JEWETT, FRANK F. An Arrangement for Washing Precipitates with Boiling Water 517

KEBLER, LYMAN F. Acidimetric Estimation of Vegetable Alkaloids 822
KILGORE, B. W. The Determination of Phosphoric Acid by the Molybdate-Magnesia Method and by Volumetric Method, 941; On the Estimation of Phosphoric Acid by Titration of the Ammonium Phosphomolybdate Precipitate with Standard Alkali 950
KONINGH, L. DE. Separation of Solid and Liquid Fatty Acids 740
KRUG, WILLIAM. H. The Determination of Tannin by Metallic Oxides 811
KRÜSS, GERHARD. (Obituary Notice) 423

LANDIS, EDWARD K. The Indirect Analysis of Mixtures Containing a Common Constituent 466
Lard analysis, phosphomolybdic acid test applied to 33
Lard, examination for impurities 723
Lead, tin, arsenic, and antimony alloys, analysis of 869
Lead, volumetric determinations of 901
LEEDS, ALBERT R. Acetic acid in vinegar 741
LENHER, VICTOR. Sulphiodide of Lead 511
LINEBARGER, C. E. On Some Experiments in the Anthracene Series, 354; On the Reaction Between Zinc Sulphate and Potassium Hydroxide, 358; On the Vapor Tensions of Mixtures of Volatile Liquids, 615, 690; On the Formation of Layers in Mixtures of Acetic Acid and Benzene 932
LONG, J. H. On Certain Phenomena Observed in the Precipitation of Antimony form Solutions of Potassium Antimonyl Tartrate, 87; Obituary Notice of Mark Powers, 586; Obituary Notice of Lothar von Meyer 664
LUNGE, G. On the Estimation of Sulphur in Pyrites 181

MCELROY, K. P. Note on the Estimation of Iron and Alumina in Phosphates 260
MCKENNA, C. F. Obituary Notice of Dr. Gideon E. Moore 659
MCPHERSON, WILLIAM. See Weber, H. A.
MCTAGGART, J. R. See Noyes, W. A.
MABERY, CHARLES F. An Examination of the Atmosphere of a Large Manufacturing City 105
Magnesium amalgam, reduction with 789
Manganese, determination of, 341; volumetric estimation of 943
MASON, W. P. Henry Bradford Nason (Obituary Notice) 339
MATTHEWS, J. MERRITT. See Smith, Edgar F.
Methane and hydrogen, determination by explosion 986
Methane and hydrogen in the atmosphere 801
MEYER, FRED L. See Smith, Edgar F.
Meyer, Lothar von (Obituary Notice) 664
MITCHELL, W. L. See Wells, H. L.
MIXER, C. J., and H. W. DuBois. The Zimmermann-Reinhardt method for the Determination of Iron in Iron Ores 405
Molding-sand 502
Molybdenum and tungsten, chemical behavior of 381
Molybdenum carbide 421
Molybdates of rare earths 483, 520
MUNROE, CHARLES E. Inspection of Cotton for use in the Manufacture of Gun-cotton 783

NASON, HENRY BRADFORD. Obituary Notice 339
Nickel in nickel steel, determination of 125
Nitric acid, condensation of, 576; points in distillation of 580
Nitrocellulose, manufacture of soluble 411
Nitrogen, determination in fertilizers containing nitrates 567
Nitroglycerol, manufacture of 263

NORTON, THOMAS H. The Contributions of Chemistry to the Methods of Preventing and Extinguishing Conflagration 137, 251, 361
NOTES. Argon: A new constituent of the atmosphere, 219; calcium sulphite, stalactites and stalagmites, 242; an improvement on the Danglers laboratory lamp, 337; spurting in cupellation, 338; a substitute for hydrogen sulphide, 338: a new hydrogen sulphide generator, 420; molybdenum carbide, 421; the gas contained in uraninite, 421; compounds of argon, 422; molding sand, 502; determination of acetic acid in vinegar, 834; the banquet to Messrs Mond and Tyrer, 997.
Noyes, Arthur A., and John T. Dorrance. The Electrolytic Reduction of Paranitro Compounds in Sulphuric Acid Solution 855
NOYES, ARTHUR A., and Willard H. Watkins. The Occurrence of Trimethylene Glycol as a By-Product in the Glycerol Manufacture 890
NOYES, W. A., and J. S. Royse. The Volumetric Determination of Phosphorus in Steel and Cast Iron 129
NOYES, W. A., J. R. McTaggart and H. W. Craver. The Determination of the Heating Effects of Coals 843

OBITUARY NOTICES. Henry Bradford Nason, 339; Gerhard Krüss, 423; Mark Powers, 586; Gideon E. Moore, 659; Lothar Von Meyer, 664; Louis Pasteur 1000
Oils, physical and chemical properties of California 935
Organic matter in fertilizers, oxidation of by aqua regia 86
OSBORNE, THOMAS B. The Proteids of the Rye Kernel, 429; The Proteids of Barley, 539; The Chemical Nature of Diastase 587

PASTEUR, Tribute to (obituary notice) 1000
PECKHAM, S. F. The Asphalt Question 55
Pelagine, composition of 877
Pemberton, H., Jr. The Determination of Phosphoric Acid 178
Penetration machine, an explanation 218
Perchromic acid, new solvents for 41
Periodides of pyridine 859
Periodic law, modified arrangement of the elements, 75; early American arrangement of the elements 947
Periodides, the 775
Phenacetine, identification of 933
PHILLIPS, FRANCIS C. On the Possibility of the Occurrence of Hydrogen and Methane in the Atmosphere, 801; The Evolution Method for the Determination of Sulphur in White Cast-Iron 891
Phosphates, estimation of iron and alumina in 260
Phosphoric acid, determination by molybdic acid process, 43; determination of, 178; determination of small quantities by citrate method, 513; reducing action of zinc on ammonium phosphomolybdate, 747; in soils estimation of, 925; determination by molybdate magnesia and volumetric methods, 941; determination by titration of ammonium phosphomolybdate precipitate with alkali 950
Phosphorus in steel and cast-iron, volumetric determination of 129
PLATT, CHARLES. See Griffith, A. B.
Potash, determination of kainite, 85; oxidation of organic matter in fertilizers in determination of, 86; determination as platinichloride 453
Potash in fertilizers, addition of calcium chloride in determination of 46
Potash in manures, determination of 47
POWERS, MARK. (Obituary Notice) 586
PRESCOTT, A. B., and P. F. Trowbridge. Periodides of Pyridine 859
PRESCOTT, A. B. The Periodides 775
Proteids of the rye kernel 429
Pyridine, peridides of 859
Pyrites, estimation of sulphur in 772

QUALITATIVE analysis of metals of iron group..... 537
QUINAN, W. R. Some Physical Aspects of the New Gas Argon, the Ideal Thermometrical Substance 477
Quinine sulphate, identification of..... 933

RAWLING, CHARLES Q. Note on a Molding Sand..... 502
ROSELL, CLAUDE A. O. The Ferrates..... 760
ROYSE, J. S. See Noyes, W. A.
RUNYAN, E. G., and H. W. Wiley. On the Determination of Small Quantities of Phosphoric Acid by the Citrate Method 513
Ruthenium, electrolytic determination of..... 652
Rye kernel, proteids of 429

SAUER, EWALD. Some New Laboratory Apparatus..... 494
SHERMAN, H. C. The Determination of Nitrogen in Fertilizers Containing Nitrates. 567
SHIMER, P. W. Note on the Determination of Zinc, 310; the Determination of Graphite in Pig-Iron 873
SHIVER, F. S. On the Standardization of Sulphuric Acid..... 351
SMITH, EDGAR F. and Daniel L. Wallace. Electrolytic Separations 612
SMITH, EDGAR F. and Fred L. Meyer. The Action of Haloid Acids in Gas Form upon the Salts of Elements of Group V of the Periodic System..... 735
SMITH, EDGAR F. and Harry B. Harris. The Electrolytic Determination of Ruthenium, 652; the Action of Phosphorus Pentachloride upon the Dioxides of Zirconium and Thorium..... 654
SMITH, EDGAR F., and Joseph G. Hibbs. Action of Hydrochloric Acid Gas upon Salts of the Elements of Group V of the Periodic System 682
SMITH, EDGAR F. and J. Merritt Matthews. Uranium Oxynitride and Uranium Dioxide 686
SMITH, EDGAR F. See Atkinson, Elizabeth A.
SNYDER, HARRY. The Action of Mineral Acids upon Soils..... 148
Soils, action of mineral acids upon, 148; apparatus for estimating the water holding power of..... 769
SPENZER, JOHN G. On the Behavior of Allylmalonic, Alylacetic and Ethylidenepropionic Acids when Boiled with Caustic Soda Solutions 1
SPRINGER, ALFRED. A Tribute to Pasteur 1000
SQUIBB, E. R. Improvement in the Manufacture of Acetone 187
Starch, quick estimation of, 64; processes used in manufacture from corn..... 68
Still for the laboratory, convenient 917
STONE, GEO. C. The Volumetric Determination of Zinc and a New Indicator for Ferrocyanide..... 473
Sugar houses, estimation of extraction in..... 920
Sulphiodide of lead 511
Sulphur, estimation in pyrites..... 181, 397
Sulphur, estimation in refined copper..... 814
Sulphur in white cast-iron, determination of..... 891
Sulphuric acid and copper, reactions between concentrated..... 904
Sulphuric acid, standardization of 351

TANNIN, determination by metallic oxides 811
Tellurium, estimation in copper bullion, 280; separation from copper residues, etc. 849
TENNILLE, GEORGE T. The Phosphomolybdic Acid Test as Applied to Lard Analysis 33
THOMAS, W. S. Methods for the Determination of Manganese..... 341
Thermometry, Use of Argon in..... 477
Tin, lead, arsenic, and antimonious alloys, analysis of..... 869
Titanic acid and iron, volumetric determination in ores 878
Titanium, warning against use of fluoriferous hydrogen peroxide in estimating..... 718
Trimethylene glycol, occurrence in glycerol 890
TROWBRIDGE, P. F. See Prescott, A. B.

TRUBEK, M. On the Estimation of the Extraction in Sugar Houses..... 920
Tungsten and molybdenum, study of chemical behavior of..... 381
Tungstates of rare earths 483, 520
TWITCHELL, E. The Separation of Solid and Liquid Fatty Acids..... 289

URANIUM oxynitride and dioxide..... 686

VAPOR tensions of volatile liquids..... 615, 690
VENABLE, F. P. A Modified Arrangement of the Elements Under the Natural Law 75; the Chlorides of Zirconium, 842; An Early American Arrangement of the Elements 947
VENABLE, F. P., and Charles Baskerville. Zirconium Sulphite..... 448
VENABLE, F. P., and Thomas Clark. Some of the Properties of Calcium Carbide.... 306
Vinegar, acetic acid in.....741, 834
Volatile liquids, vapor tensions of mixtures of..... 615, 690
Volumetric analysis. Determination of phosphorus in steel and cast-iron. 129; determination of phosphoric acid, 178; the wet assay for copper, 346; standization of sulphuric acid, 351; determination of iron in iron-ores. 405; determination of zinc, 473; impurity in hydrogen peroxide, 718; determination of acetic acid, 741, 834; estimation of vegetable alkaloids, 822; determination of titanic acid and iron in ores, 878; determination of lead, 901; estimation of phosphoric acid in soils, 925; determination of phosphoric acid, 941; estimation of manganese, 943; determination of phosphoric acid..... 950

WALKER, PERCY H. On the Use of Organic Bases in the preparation of Barium and Calcium Ferrocyanides 927
WALLACE, DANIEL L. See Smith, Edgar F.
WAIT, CHARLES E. A Convenient Still for the Laboratory 917
Washing precipitates with boiling water, arrangements for..... 517
Water Analysis, improved method of..... 296
Water-oven and still, new form of..... 122
WEBER, H. A. and William McPherson. On the Determination of Cane Sugar in the Presence of Commercial Glucose, 312; On the action of Acetic and Hydrochloric Acids on Sucrose..... 320
WELLS, H. L. and W. L. Mitchell. On the Volumetric Determination of Titanic Acid and Iron in Ores..... 878
WENDER, DR. NEWMAN. The Viscosimetric Examination of Butter for Foreign Fats 719
WESSON, DAVID. The Examination of Lard for Impurities..... 723
WHITEHEAD, CABELL. Estimation of Tellurium in Copper Bullion, 280; Tellurium: Its Separation from Copper Residues with Notes on Some New Reactions..... 849
Paranitro compounds, electrolytic reduction of 855
White lead, electrolytic process for manufacture of..... 835
WHITEFIELD, J. EDWARD. See Blair, A. A.
WILEY, HARVEY W. The Synthetic Food of the Future 155
See also Runyan, E. G.
WILLIAMS, C. B. Estimation of Phosphoric Acid in Soils by Double Precipitation with Molybdate Solution and Titration of the Ammonium Phosphomolybdate with Standard Alkali 925
WILLIAMS, R. P. An Electrolytic Process for the Manufacture of White Lead 835
Wines, coloring matter in California red..... 213
WINTON, A. L. On Some Conditions Affecting the Accuracy of the Determination of Potash as Potassium Platinichloride..... 453

ZINC, determination of, 310; volumetric determination of..... 473
Zinc sulphate and potassium hydroxide, reaction between..... 358
Zirconium and thorium dioxides, action of phosphorus pentachloride upon..... 654
Zirconium, chlorides of..... 842
Zirconium sulphite 448

Issued with December Number, 1895.

Proceedings.

COUNCIL.

The following have been approved by the Council:

By-Law.—If any member who is already a Councilor or Director shall be elected to an office which makes him *ex-officio* a Councilor or Director, the acceptance of such office shall be considered to involve the resignation of his former position as Councilor or Director, and the position so vacated shall be filled in the manner prescribed by the constitution.

Resolution.—Ordered that the dues for membership for 1896 be collected by the General Secretary as in the current year, and that he be allowed 10 per cent. on all collections as compensation for his work.

Cleveland has been designated as the place for the coming annual meeting, to be held on Monday and Tuesday, December 30 and 31, 1895.

The bill of the Chemical Publishing Co. for $256.95, for the October number of the Journal, has been approved.

NEW MEMBERS ELECTED NOVEMBER 2, 1895.

Asbury, S. E., West Raleigh, N. C.
Atkinson, Miss Elizabeth A., 125 W. Tulpehocken St., Germantown, Philadelphia, Pa.
Best, Otto, Ph.D., care N. Y. Tartar Co., 9th St. and Gowanus Canal, Brooklyn, N. Y.
Bizzell, J. A., West Raleigh, N. C.
Conklin, E. S., care S. S. White Dental Mfg. Co., Prince's Bay, Staten Island, N. Y.
Dow, Allan Wade, District Building, Washington, D. C.
Hall, Clarence A., 3220 Powelton Ave., Philadelphia, Pa.
Hayes-Campbell, J., 327 Washington, St., Newport, Ky.
Hollick, Herbert, Easton, Pa.
Lewis, Gerald, Box 70, South Bethlehem, Pa.
Love, E. G., Ph.D., 80 East 50th St., N. Y. City.
Ludlow, Gabriel, Sharpsville, Pa.
Mallory, J. Halsey, 361 Monroe St., Brooklyn, N. Y.
Semans, Wm. O., Delaware, Ohio.
Shepherd, Frank I., Kyle, Ohio.
Way, A. B., New Brunswick, N. J.
Wentworth, Walter V., Ticonderoga, N. Y.
Williams, Herbert M., B.S., 124 St. James Place, Brooklyn, N. Y.

ASSOCIATES ELECTED NOVEMBER 2, 1895.

Church, Herbert Kenneth, 112 Martien Hall, Lafayette College, Easton, Pa.
Hopkins, N. Monroe, 1730 I St., N. W., Washington, D. C.
Louder, J. Willis, South Easton, Pa.
Parker, W. F., New Brunswick, N. J.
Sigman, Alfred S., Easton, Pa.
Thatcher, Charles J., Easton, Pa.

CHANGES OF ADDRESS.

Behr, Arno, 2266 Second St., San Diego, Cal.
Bolton, H. Carrington, Cosmos Club, Washington, D. C.
Dains, F. B., 2421 Dearborn St., Chicago, Ill.
Ford, Allen P., care of Crane Co., 12th and Canal Sts., Chicago, Ill.
Forrest, Chas, N., Room 462, Central Power Sta., 14th and Penna. Ave., Washington, D. C.
Guild, Frank N., Wesleyan Univ., Middletown, Conn.
Harrison, Herbert E., Box 15, Trenton, Mich.
Herrick, Wm. Hale, 207 Greenwich St., New York City.
Hodge, H. B., 1300 Pennsylvania Ave., Washington, D. C.
Mallory, J. Halsey, 539A Green Ave., Brooklyn, N. Y.
Tucker, Francis T., 1720 M St., Lincoln, Neb.

MEETINGS OF THE SECTIONS.

CHICAGO SECTION.

A meeting of the Chicago Section of the American Chemical Society was held October 15.

A Note on the precipitation of zinc in acid solution was presented by Prof. J. B. Nagelvoort.

Dr. J. H. Long gave the results of some experiments on the precipitation of antimony cinnabar from solutions of tartar emetic by means of sodium thiosulphate.

Mr. C. L. Kennicott read some correspondence between Alfred Allen and Mr. Bannister, of Somerset House, Eng.

NEW YORK SECTION.

The October meeting of the New York Section was held in the University Building, Prof. P. T. Austen in the chair.

Prof. Austen was re-elected Presiding Officer for the ensuing year. Dr. Durand Woodman was elected Secretary and Treas-

surer. Profs. A. H. Sabin, A. C. Hale and A. R. Leeds were elected as Executive Committee. Messrs. McKenna and Hale were elected to act with the chairman as delegates to the Council of the Scientific Alliance. Prof. Hale reported for the delegates to this Council for 1894–95. On motion, his report was accepted.

The chair appointed a committee of two to act with the New York Section of the Society of Chemical Industry in giving a complimentary dinner to Messrs. Tyrer and Mond.

The chairman also appointed a committee to draw up suitable resolutions upon the death of Pasteur, the same to be signed by the Chairman and Secretary and forwarded to the French Chemical Society. Messrs. Squibb and Loeb were appointed.

A paper on "Progress of Chemcal Work in the Agricultural Experiment Station," was read by E. B. Voorhees; "On the Development of Colors on Vegetable Fibers," by Dr. Baker; "A Laboratory Note Book," "Cold Production of Oxygen," "A Specimen Bottle," and "The Commercial Production of Haematein," by Prof. P. T. Austen; "Quantitative Volumetric Determination of Orcinol," by H. S. Neiman.

The meeting of November 8th was held in the hall of the Mott Memorial Library at 64 Madison Ave., New York, Prof. P. T. Austen in the chair.

The minutes of the previous meeting were read and approved.

The Secretary reported that the letter authorized to be prepared in regard to the death of Louis Pasteur, had been received from the Committee, and duly forwarded to the French Chemical Society.

Prof. W. P. Mason's paper on "The Chemical vs. the Biological Examination of Water" was read by Prof. McMurtrie, in the absence of the author.

In the discussion which followed, the opinion was general, that to arrive at a sound conclusion, it is necessary to make both examinations, and in addition, the history of a water should be known as accurately as possible.

Prof. McMurtrie stated that in examining a large number of wells in the State of Illinois, he had found no cases of typhoid fever from the use of well waters in which the nitrites, free and albuminoid ammonia were all low.

These determinations, in conjunction with careful investigation of the history of a water he had found a pretty safe guide to an opinion.

Dr. Horne described an interesting case of large increase of nitrites in mixing three water supplies, the nitrites being low in each of the waters tested separately. Prof. Speyers suggested that the presence of hydrogen sulphide, or other reducing agent in one of the waters, acting on nitrates in the others might account for this phenomenon.

A paper "On the Heat of Solution of Certain Carbon Compounds" was read by Prof. C. L. Speyers.

Dr. Austen read a "Note on Runge's 'Bildungstrieb' of Substances" and exhibited a copy of this old and rare work.

Mr. Cutts read a paper by T. S. Gladding, "On the Gravimetric Method of Determining Phosphoric Acid by the Phospho-Molybdate Method."

"Specimens showing the Effects of Gun-Cotton Explosions" were exhibited by Mr. W. H. Burleigh.

The meeting was then adjourned to the second Friday in December.

WASHINGTON SECTION.

The Washington Section of the American Chemical Society held a meeting on May 9th, President Munroe in the chair. Forty members were present. Marion Dasett and S. C. Miller were elected to membership.

The first paper was read by Dr. E. A. de Schweinitz on a new Meteorite from Forsyth County, N. C. The second was by Dr. Peter Fireman, on "Hydrogen Fluoride Poisoning." Discussion by Messrs. Munroe, Brown and Chatard. Prof. Munroe thought that cases like that of Dr. Fireman should be brought together in order that similar accidents could be guarded against and remedies provided. Mr. Brown referred to a work in French upon such accidents; Dr. Chatard referred to similar experiences of his own with hydrogen fluoride. The next paper was by Dr. W. H. Seaman, on "Progress in the Manufacture of Artificial Musk." He stated that the artificial product is a commercial article, and traced its history from the time it was first prepared in 1759 by Markgrof down to the present time, refer-

ring to the different patents issued for artificial musk. The one most known is the Musk Bauer. None of the compounds are in any specific sense artificial musk. A large number of nitro bodies possess valuable odors and synthetic chemistry is trying to supplant the natural bodies. In the manufacture of soap the artificial substance is extensively used.

The subject for discussion for the evening was "The Chemical Action of Micro-organisms." Dr. de Schweinitz opened the discussion by referring to the difficulty of treating the subject in a limited time, and spoke of the vast number of micro-organisms by which changes in the mineral, animal and vegetable kingdoms are produced and of the very few that up to the present time had been isolated and studied. He then described the substances resulting from the fermentations of glucose alcohol and the part played by the different germs in these fermentations and of their selective action. Different germs acting upon the *same* substance produce different results, and the same germ acting upon *different* substances produce the same results. The products of pathological bacteria are complex and difficult to isolate, but it is to them that the fatal effects of diseases are to be attributed. The poisonous products belong for the most part to the toxines that have been isolated from cultures of the different bacilli: tetanus, cholera, diphtheria, tuberculosis and glanders. The albuminoids for the most part are rich in phosphorus, and seem to be more nearly like the nucleins. The quantity produced is so extremely small that it is difficult to make absolute identifications, but they are extremely virulent even in most minute quantities. The pathological power of germs is often decreased or diminished; they become attenuated and are no longer fatal in their effects, either because they do not find the soil adapted to their multiplication or because the amount of active poison secreted is too small. The germs are interesting also on account of the composition of their own bodies; this is constant, but different for different forms. The proximate constituents are varied. For instance, the percentage of fat is very different in the different bacilli. Some of the germs produce cellulose and others do not. The different effects produced by them must result from the internal structure of the molecules.

Surgeon General Sternberg, who was present as a guest, gave a brief outline of some of the products of pathological bacteria, referring to the work of Brieger, Pfeiffer, Kitasato and others. The toxines may be acids or bases unstable, or united with the colloid bodies. "Toxalbumens" may be continued as the term to apply to them.

Prof. Wiley said that micro-organisms were at work in the interest of the farmer long before there were any medical schools. He referred to the intimate relations that existed between certain minute organisms and the chemical reactions which take place in the soil.

Prof. George P. Merrill, who was present as a guest, was called upon and said that he was not quite so enthusiastic as Dr. Wiley upon the part micro-organisms played as rock destroyers. They have been found in rocks that are highly decomposed, but he thought it had not been proved that they caused the decomposition. He looked at the subject from a conservative standpoint, partly from the fact that it is one that few geologists have investigated. In the District of Columbia he thought mechanical agencies were more potent than chemical action as rock destroyers. Rocks that disintegrated to the depth of fifty feet lost three per cent. or less of their original constituents. The disintegration goes to the depth of 200 feet. He thought the action of bacilli has been overestimated.

The Society at 10 P. M. adjourned until November.

CINCINNATI SECTION.

A meeting of the Cincinnati Section was held on November 15, 1895, Dr. Alfred Springer presiding.

In an interesting talk on "The Glycerol Industry," Mr. Joseph Feemster described the various processes that have been used in the manufacture of glycerol and exhibited samples representing different stages of the process, and the several grades of glycerol now on the market.

In a paper on "The Recent Progress in Cellular Chemistry," Dr. S. P. Kramer gave a resumé of the latest advances in microchemical work.

Mr. F. I. Shepherd, of this city, and J. Hayes-Campbell, of Newport, Ky., were elected members of the Section.

A Laboratory Work Indispensable to the Analyst.

Notes on Metallurgical Analysis. By N. W. Lord. 101 pp. Price $1.25. Giving Methods of Sampling; Determinations of Iron, Phosphorus, Silicon, Manganese, Sulphur, Carbon and Titanium; Analysis of Coal and Coke, Gas, Slag and Fire-Clays; Determination of Copper and Zinc in their Ores; Examination of Water for Boiler Supply.

Valuable Treatise on the Examination of Clays.

THE CHEMISTRY OF POTTERY. By Karl Langenbeck. 197 pp. Price $2.00, bound in flexible cloth.

A GUIDE TO STEREOCHEMISTRY. By Arnold Eiloart. Price, $1.00.

PRINCIPLES AND PRACTICE OF AGRICULTURAL ANALYSIS. By Harvey W. Wiley. Published in monthly parts, 25 cents each, $3.00 a year. Vol. I now ready, bound in Cloth, price, $3.75. Vol. II now ready, bound in Cloth, price, $2.00. Send for prospectus.

ALEMBIC CLUB REPRINTS, 50 cents each.

No. 1. "Experiments upon Magnesia Alba." By Joseph Black, M.D., (1755) 47 pp.

No. 2. "Foundations of the Atomic Theory." Papers by Dalton Wallaston and Thomson, (1802-1808) 48 pp.

No. 3. "Experiments on Air." Papers by Hon. Henry Cavendish, F. R. S., (1784 1785) 52 pp., illustrated.

No. 4. "Foundations of the Molecular Theory." Papers by Dalton, Gay-Lussac and Avogadro, (1808-1811) 51 pp.

No. 5. "Extracts from Micrographia." By Robert Hooke, F. R. S., (1665) 52 pp.;

No. 6. "The Decomposition of the Fixed Alkalies and Alkaline Earths." By Humphrey Davy, (1807-1808) 51 pp.

No. 7. "The Discovery of Oxygen." Part I, by Joseph Priestly, LL.D., (1775) 55 pp.;

No. 8. "The Discovery of Oxygen." Part II, by Carl Wilhelm Scheele, (1777) 46 pp.

No. 9. "The Elementary Nature of Chlorine." By Humphrey Davy, (1809-1818) 77 pp.

No. 10. "Researches on the Arseniates, Phosphates and Modifications of Phosphoric Acid." By Thomas Graham, F. R. S., (1833) 45 pp.

No. 11. "The Increase in Weight of Tin and Lead on Calcination." By Jean Rey, (1630) 54 pp.

Other Numbers Will Follow.

PAMPHLETS

Hints to Beginners in Iron Analysis. By DAVID H. BROWN. Price, 15 Cents.

The Pierce Process for the Production of Charcoal, Wood Alcohol, and Acetic Acid. By WM. L. DUDLEY. Price, 10 Cents.

CHEMICAL PUBLISHING CO., EASTON, PA.

BAKER & ADAMSON,

Manufacturing Chemists,

EASTON, PA.

Strictly Chemically Pure Muriatic,

Nitric, and Sulphuric Acids and Ammonia.

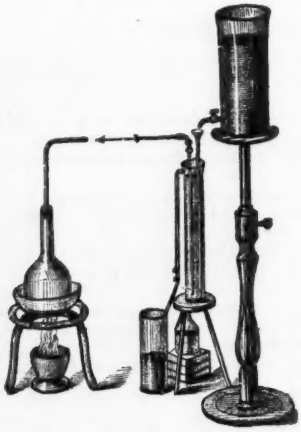
Chemically Pure Salts.

Ashless Filter-Papers, washed in hydrochloric and hydrofluoric acids, cut in all sizes, and put up in boxes holding 100 papers each.

Ribbed Filter Paper, washed in hydrochloric acid, for qualitative work, cut in all sizes.

For Sale by All Dealers.

Price list sent on application



CHEMISTRY

—)AND(—

CHEMICAL APPARATUS.

POLARISCOPES AND SPECTROSCOPES, HAMMERED PLATINUM, BOHEMIAN GLASS AND PORCELAIN, SCHLEICHER AND SCHÜLL'S FILTERS, ZEISS' MICROSCOPES.

LABORATORY OUTFITS

A SPECIALTY.

EIMER & AMEND, NEW YORK.

Glassblowing Done on the Premises

STANDARD BOOKS ON CHEMISTRY.

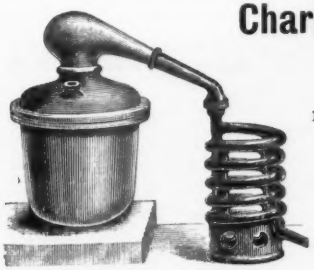
Richter's Inorganic Chemistry. Trans. by Smith; 4th edition, 89 illustrations. $2.00.
Richter's Organic Chemistry. Trans. by Smith; 2nd edition. $4.50

*** *Richter's books are recommended in many of the best schools.*

Smith and Keller, Experiments in General Chemistry. 2nd edition. *Net*, 60 cents.
Smith's Electro-Chemical Analysis. 2nd edition, illustrated. $1.25.
Bloxam's Chemistry, Inorganic and Organic. Illustrated. 8th edition. *In press.*
Caldwell's Qualitative and Quantitative Chemical Analysis. 3rd edition. *Net* $1.50.
Leffmann's Water Analysis. 2nd edition, illustrated. $1.25.
Leffmann's Analysis of Milk and Milk Products. Illustrated. $1.25.
Leffmann-Weyl. The Coal Tar Colors. $1.25.
Bartley's Medical and Pharmaceutical Chemistry. 3d edition, illustrated. $3.00.
Sutton's Volumetric Analysis. 6th edition, illustrated. $5.00.
Clowes' Elementary Qualitative Analysis. Illustrated. *Net* $1.00
Groves and Thorp. Chemical Technology. Vol. I, Fuels. $7.50. Vol. II, Lighting. *In press.*

Catalogues of these and other books free.

P. BLAKISTON, SON, & CO.,
1012 WALNUT ST., PHILADELPHIA.



SEND FOR CATALOGUE.

Charles Graham Chemical Pottery Works,

BROOKLYN, N. Y.

Manufacturers of —

CHEMICAL VESSELS

TO THE SIZE OF 500 GALLONS.

Any Description of Stoneware Chemical Apparatus Made to Order.

• • Journal of • •

The American Chemical Society,

Vols. I to XVI.

COMPLETE SETS of this Journal

MAY BE HAD OF

The Librarian F. E. DODGE,

* * * * * * Box 85, Long Island City, N. Y.

AT THE RATE OF

$3 A VOLUME TO MEMBERS - -
- $5 A VOLUME TO NON-MEMBERS.

Single Numbers of Any Issue May Also Be Obtained At Proportionate Rates.

Bullock & Crenshaw,

528 ARCH ST., PHILADELPHIA.

—— Sole Manufacturers of ——

DOOLITTLE'S
TORSION VISCOSIMETER.

—— Sole Agents for ——

Dreverhoff's Filter Papers, The best washed Filters made.

SEND FOR SAMPLES AND PRICES.

Marquart's C. P. Chemicals.
Baker & Adamson's C. P. Chemicals.

LABORATORY APPARATUS OF EVERY DESCRIPTION

Munktell's Swedish Filter-Papers.
Bohemian Glassware.

YOUNG MEN TO STUDY CHEMISTRY

Are wanted by the Chemical Department of Lafayette College. Applications for good men to fill responsible positions are constantly received. The present demand for chemists from this laboratory is largely in excess of the supply.

Applicants for admission will be examined in English Grammar, Franklin's Autobiography, Paradise Lost (two books), English Prose Composition, Modern Geography, the General Outlines of History, Elementary Natural Philosophy, Arithmetic, Metric System, Algebra (through Quadratics, as in Davies' Bourdon), Plane Geometry (six books of Davies' Legendre, or an equivalent). Tuition, $111 a year; laboratory expenses, about $65 a year. Board, room rent, fuel, and washing, about $250 a year. *Certificates of good moral character will be required. Only those willing to work need apply.* Graduates receive the degree of B. S.

The other college courses are as follows: CLASSICAL, GENERAL SCIENTIFIC, LATIN SCIENTIFIC, CIVIL ENGINEERING, MINING AND METALLURGY, ELECTRICAL ENGINEERING, and POST-GRADUATE. For further information address

S. L. FISLER, A. M., *Secretary, Easton, Pa.*

EMIL GREINER

CHEMICAL GLASSWARE.

LABORATORY OUTFITS.

146 and 148 William Street, New York.

Apparatus to Order, a Specialty.

Established 1842.

J. BISHOP & CO.,

REFINERS AND MELTERS OF

PLATINUM.

Old Platinum Bought and Taken in Exchange.

Scrap Melted at the Shortest Notice.

Sugartown,

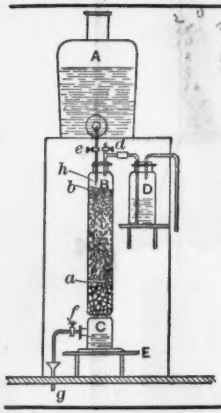
Chester Co, Pa.,

MANUFACTURERS OF

Crucibles, Evaporating Dishes, Ignition Tubes,

And All Articles Made from Platinum Used by Analytical Chemists.

All articles sent by Adams Express directed to J. Bishop & Co., Malvern Station, P. R. R., will meet with prompt attention. Circulars sent free on application.



WOOD & COMER

(LIMITED)

Of 130 Juvenal St., Philadelphia,

MANUFACTURE

Special :: Apparatus

AND DEAL IN

CHEMICALS, ...

CHEMICAL APPARATUS,

GENERAL SCIENTIFIC SUPPLIES,

ASSAY GOODS.

* Harris Comer was for seven years with Queen & Co.

Wm. Pickhardt & Kuttroff.

(Badische Anilin & Soda Fabrik, Special Partner.)

98 Liberty St., New York.

ANHYDROUS SULPHURIC ACID

also Fuming, all strengths.

NEWARK WOOD-WORKING CO.,

142-150 North Canal Street, ... Newark, N. J.

MANUFACTURERS OF

WOOD FILTER PRESS PLATES AND FRAMES,

MADE FROM WHITE AND YELLOW PINE, ASH, MAPLE, OR ANY DESIRED WOOD.

PRICES FURNISHED UPON APPLICATION. **CORRESPONDENCE SOLICITED.**

We can refer to many parties for whom we are making these goods.

THOS. M. CLARK, Treasurer.